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Determinants of the impact of Quantitative Easing policy on the link between bank loans growth and capital ratio in Europe

Doctoral dissertation

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Warsaw, 2021

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Abstract

The dissertation seeks to establish determinants of the European Central Bank's (ECB) Quantitative Easing (QE) policy impact on the relationship between bank lending growth and capital ratios in Europe. It identifies a research gap at the intersection of two research areas, namely finance and banking (the capital regulatory perspective) and central banking (the monetary policy perspective). Accordingly, the thesis focuses on bank capital and monetary policy as determinants of bank lending. It builds on a body of research that emerged in the aftermath of the 1990-1991 recession in the US. In most studies, it is argued that a sudden and sharp decline in bank credit (i.e., credit crunch) at that time was a consequence rather than a cause of the capital crunch in the US banking sector. In later years, especially in the aftermath of the Global Financial Crisis, many authors examined various bank-specific characteristics as potential determinants of the link between bank capital (ratios) and bank loan growth.

According to the literature reviewed in Chapter 1, among the most important factors influencing the studied link are bank size, liquidity ratios, and an initial level of a capital ratio (cf. Brei, Gambacorta, & von Peter, 2013; Kim & Sohn, 2017). Furthermore, reviewed studies report that bank capital and credit relationship is essentially non-linear and, in most cases, positive. The obtained results confirm this evidence. Many post-crisis empirical studies, in particular Berrospide & Edge (2010); Carlson et al. (2013); Kim & Sohn (2017); Mora & Logan (2012); Olszak et al. (2017) have in fact also supported the view of a positive link existing between bank lending growth and capital adequacy ratios. Importantly, the obtained results support the 'risk absorption' theory and undermine the alternative 'financial fragility-crowding out' hypothesis (see Berger & Bouwman, 2009). The complex and non-linear nature of studied relationship is illustrated with the originally proposed 'circular pyramid' that links this non-linear relationship between bank capital and credit to a range of factors such as a phase of economic cycle, credit market dynamics, bank profits, loan loss provisions and the stock market. The proposed approach is consistent with the endogenous theory of money, financial accelerator view and the asymmetric information theory.

Chapter 2 focuses on standard and unconventional monetary policy transmission channels. Based on the original model of a general monetary transmission mechanism, and on the 'decoupling principle' of Borio & Disyatat (2009), I examined effects of both types of monetary policy. Direct effects of non-standard policy measures such as QE works mainly via the portfolio rebalance channel, within which the scarcity, signaling and duration effects can be distinguished. All three effects cause the central bank's purchases to crowd out other market participants' demand, and thus increase prices and decrease yields of the purchased bonds, lowering long-term interest rates. The other broad channel of propagation of QE purchases is bank risk-taking which is significantly intensified in the current low interest rate environment (Gambacorta, 2009). Chapter 3 describes the empirical method, data sources, initial data treatment, and econometric models. Within-groups and between fixed effects estimators as well as random effects and hybrid models are presented. The results support the view of high heterogeneity among European banks with regard to their size.

In Chapter 4, I estimated fixed-effects econometric models based on the sample of annual data which in its final form – i.e., adjusted for outliers and M&As – contains

institution-level panel data on 2,335 banks from 47 European countries observed in the 2011-2018 period. The results indicate that the ECB's unconventional policy was a significant factor that affects the relationship between bank loans growth and key capital ratios. Furthermore, the results show that this relationship depended on a number of bank-specific factors, namely bank size and specialization, bank's initial level of capitalization, and a liquidity ratio. In addition, country-specific factors are also found to be valid determinants of the QE impact on the studied link. The effect of regulatory capital ratios on bank lending is negatively associated with the QE policy for banks from countries with more restrictive capital regulations; whereas said effect is found to be positively associated with the QE policy only for banks from countries with less concentrated banking sector and with low share of state-owned banks.

A major finding of the thesis is that QE policy in the form of the ECB's Asset Purchase Program has strengthen the positive link between regulatory capital ratios and bank loan growth in Europe. Since this finding is robust to using the alternative liquidity ratio across all adopted measures of a capital ratio, it can be regarded as a contribution to the literature. The QE policy in Europe has been successful in making banks more responsive to capital ratios in their lending activities. This policy thus contributed to removing a liquidity constraint for less liquid banks, but also it has made them more responsive (i.e., less resilient) to capital shocks. This evidence implies that policy actions should be aimed both at improving bank liquidity and at the same time providing banks with resources to strengthen their capital ratios, for example by state-contingent capital injections or bank equity purchases programs.

Keywords

capital ratios, bank lending, unconventional monetary policy, European Central Bank, Quantitative Easing, bank liquidity, capital adequacy requirements, credit crunch

Determinanty wpływu polityki luzowania ilościowego na relację między stopą wzrostu kredytu bankowego a współczynnikami kapitałowymi banków w Europie

Abstract in Polish

Celem dysertacji jest określenie determinantów wpływu polityki luzowania ilościowego (polityka QE) prowadzonej przez Europejski Bank Centralny (EBC) na relację między wzrostem kredytu bankowego a współczynnikami kapitałowymi banków funkcjonujących w Europie. Niniejsza praca doktorska identyfikuje lukę badawczą na przecięciu dwóch obszarów badawczych: finansów i bankowości (perspektywa kapitałowo-regulacyjna) oraz bankowości centralnej (perspektywa polityki monetarnej). W związku z tym niniejsza dysertacja skupia się na kapitałach bankowych oraz polityce pieniężnej jako determinantach akcji kredytowej banków. Praca w głównej mierze opiera się na badaniach prowadzonych po wybuchu recesji z lat 1990-1991 w Stanach Zjednoczonych. Większość badań wskazuje, że nagłe i znaczące załamanie się podaży kredytu bankowego (krach kredytowy) w tym czasie było konsekwencją a nie przyczyną nagłego spadku kapitałów własnych banków (krach kapitałowy) w amerykańskim sektorze bankowym. W kolejnych latach, w szczególności po wybuchu Globalnego Kryzysu Finansowego, wielu autorów zaczęło badać różne charakterystyki bankowe jako potencjalne determinanty relacji zachodzącej między współczynnikami kapitałowymi banków a wzrostem ich akcji kredytowej.

Z przeprowadzonego w Rozdziale 1. przeglądu literatury wynika, że do najważniejszych czynników wpływających na badaną relację należy zaliczyć: rozmiar banku, współczynniki płynnościowe oraz początkowe wskaźniki kapitałowe (por. Brei, Gambacorta, & von Peter, 2013; Kim & Sohn, 2017). Ponadto, analizowane badania wskazują, że związek między kapitałami bankowymi a kredytem bankowym jest w gruncie rzeczy nieliniowy i w większości przypadków jest dodatni. Uzyskane w niniejszej rozprawie wyniki potwierdzają te obserwacje. Wiele powstałych po kryzysie badań empirycznych, w szczególności Berrospide & Edge (2010); Carlson et al. (2013); Kim & Sohn (2017); Mora & Logan (2012); Olszak et al. (2017) potwierdza dodatni związek występujący między wzrostem kredytu bankowego a współczynnikami adekwatności kapitałowej. Co ważne, uzyskane rezultaty potwierdzają teorię „absorbcji ryzyka”, w ten

sposób podważając alternatywną hipotezę o „finansowej kruchości i efekcie wypierania” (zob. Berger & Bouwman, 2009). Złożona i nieliniowa natura badanej relacji jest zobrazowana przez autorski schemat „kołowej piramidy”, który łączy tą nieliniową relację między kapitałami bankowymi a kredytem z wieloma czynnikami takimi jak: faza cyklu koniunkturalnego, dynamika rynku kredytowego, zyski bankowe, odpisy na rezerwy kredytowe oraz rynek akcji. Zaproponowane podejście jest zgodne z endogeniczną teorią pieniądza, teorią akceleratora finansowego oraz z teorią asymetrii informacji.

Rozdział 2. analizuje kanały transmisji standardowej i niekonwencjonalnej polityki monetarnej. Na podstawie autorskiego modelu ogólnej transmisji impulsów monetarnych, a także bazując na „zasadzie rozłączenia” zaproponowanej w pracy Borio & Disyatat (2009), przebadałem skutki obu rodzajów polityki monetarnej. Bezpośrednie skutki niestandardowych instrumentów polityki pieniężnej takich jak polityka QE oddziałują kanałem „powrotu do równowagi portfelowej”, wewnątrz którego można wyróżnić efekt rzadkości, efekt sygnalizacyjny i efekt duracji. Te trzy efekty powodują wypieranie popytu inwestorów przez zakupy aktywów przez bank centralny, działając w kierunku wzrostu cen kupowanych obligacji i spadku ich rentowności, co ostatecznie powoduje redukcję poziomu długoterminowych stóp procentowych. Innym kanałem propagacji zakupów w ramach polityki QE jest kanał ryzyka podejmowanego przez banki. To ostatnie zjawisko uległo intensyfikacji w ostatnich latach – w warunkach niskich stóp procentowych (Gambacorta, 2009). Rozdział 3. opisuje zastosowaną metodę empiryczną, źródła danych, wstępną analizę i przygotowanie danych oraz wykorzystane modele ekonometryczne. W szczególności są w nim opisane wewnątrzgrupowe oraz pomiędzy grupowe estymatory efektów stałych jak również estymatory efektów losowych i modele hybrydowe. Wyniki wstępnej analizy pokazują, że istnieje wysoka heterogeniczność pośród europejskich banków w odniesieniu do ich rozmiaru.

W Rozdziale 4. oszacowałem ekonometryczne modele estymatorem efektów stałych na próbie rocznych danych panelowych, które w ostatecznej formie – tj. po dostosowaniu ich pod względem obserwacji odstających oraz fuzji i przejęć (M&As) – zawierają dane o 2355 indywidualnych bankach pochodzących z 47 europejskich krajów obserwowanych w latach 2011-2018. Wyniki wskazują, że niekonwencjonalna polityka

EBC była istotnym czynnikiem oddziałującym na relację między wzrostem kredytu bankowego a kluczowymi współczynnikami kapitałowymi. Ponadto, wyniki pokazują, że ta relacja zależała od wielu czynników specyficznych dla pojedynczych banków, takich jak rozmiar, specjalizacja, początkowe wskaźniki kapitałowe i współczynniki płynnościowe. Dodatkowo, czynniki specyficzne dla krajów również okazały się być istotnymi determinantami wpływu polityki QE na badaną relację. Wpływ regulacyjnych współczynników kapitałowych na akcję kredytową jest negatywnie powiązany z polityką QE dla banków z krajów o wysoce restrykcyjnych regulacjach kapitałowych; natomiast ten sam wpływ jest dodatnio powiązany z polityką QE w przypadku banków pochodzących z sektorów bankowych o niskiej koncentracji oraz o niskim udziale banków będących własnością państwa.

Ważny wniosek płynący z niniejszej rozprawy jest taki, że polityka QE w formie programu *Asset Purchase Program* realizowanego przez EBC wzmocniła dodatnią relację zachodzącą między regulacyjnymi współczynnikami kapitałowymi a wzrostem kredytu bankowego w Europie. Ponieważ wniosek ten jest odporny na zmianę wykorzystywanego współczynnika płynnościowego dla wszystkich przyjętych wskaźników kapitałowych, można uznać go za istotny wkład do literatury. Polityka QE w Europie okazała się być skuteczna pod względem zwiększania elastyczności akcji kredytowej banków na zmiany współczynników kapitałowych. W ten sposób ta polityka przyczyniła się do zmniejszenia skali problemów płynnościowych w przypadku mniej płynnych banków, choć z drugiej strony doprowadziła do zwiększenia ich responsywności (tj. zmniejszenia odporności) na szoki kapitałowe. Ten fakt sugeruje, że działania decydentów gospodarczych powinny być nakierowane zarówno na poprawianie sytuacji płynnościowej banków, jak i jednocześnie na dostarczanie bankom zasobów do wzmacniania ich współczynników kapitałowych, na przykład poprzez wprowadzenie zależnego od warunków rynkowych programu dokapitalizowania banków albo programów zakupu udziałów bankowych.

Keywords in Polish

współczynniki kapitałowe, kredyty bankowe, niekonwencjonalna polityka monetarna, Europejski Bank Centralny, luzowanie ilościowe, płynność bankowa, wymogi adekwatności kapitałowej, krach kredytowy

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Introduction

Monetary macroeconomics and banking are research fields that have attracted a considerable amount of attention both from scholars and financial markets practitioners since the outburst of the Global Financial Crisis (GFC). A considerable change in research programs of these two groups has been a shift in the emphasis put on the role of banks in the modern economy. The role of banks as only pure financial intermediaries is now being directly challenged by a number of authors, including some eminent economists, notably from the International Monetary Fund (IMF), and from major central banks such as Bank of England (see Jakab & Kumhof, 2015, 2019). These economists have recently reemphasized the role of banks as credit providers and hence bank money and credit creators.

Bank credit and lending behavior has thus become the core of many research programs in the field of monetary macroeconomics and banking. There are multiple reasons for this state of affairs. In what follows, I will discuss three of them.

Firstly, in modern economies it is private profit-maximizing banks that create the vast majority of the money supply through their bank lending (Bachurewicz, 2019; McLeay, Radia, & Thomas, 2014; Werner, 2014).

Secondly, credit created through excessive bank lending practices crucially contributed to the recent GFC and the resultant period of the Great Recession. Since banks imprudently granted too many too risky loans (widely dubbed “subprime” lending) and then processed, repackage and sold them as derivatives to other financial institutions and investors, following the ‘new’ originate-and-distribute model of banking (Adrian and Shin, 2010), the financial stability has become an all-important issue.

Thirdly, bank credit is a major source of financing for many small and medium-sized enterprises (SMEs) and large firms in Europe, in addition to being a vital and necessary factor for sustaining economic growth in the whole European macroeconomy[1]. This stems from the observation that European financial systems in many cases (i.e., primarily German, Austrian, Danish, Italian, Greek, Portuguese, and Spanish economies)

[1] It was early recognized by Schumpeter (1934) that credit and entrepreneurship are two necessary ingredients for the economic growth and prosperity, when he wrote that “the new combination of means of production and credit are the fundamental phenomena of economic development” (Schumpeter, 1934, p. 74).

rely extensively on the bank credit provision and deposit intermediation, consequently being, on the whole, relatively more a bank-based financial system, which resembles more the Japanese model of financial system rather than the US model that is more market-based system (see Bijlsma & Zwart, 2013).

Having emphasized the importance of bank credit and lending activities, it is now crucial to elaborate on the potential determinants of bank lending. Obviously, there exists demand- and supply-related factors that can affect the volume of bank lending. The demand-side factors are often related to aggregate business cycle variables, such as GDP growth, unemployment rate, investment and consumption growth[2]. In the present dissertation, while demand-side factors are considered, they do not constitute the main focus of the research. Considerable attention is, on the other hand, devoted to the study and gaining understanding of the mechanics and relative importance of the supply-side determinants of bank lending.

As already pointed out in numerous articles and studies (Bachurewicz, 2019; Bundesbank, 2017; de Boyer, 1998; McLeay, Radia, & Thomas, 2014a; Sheard, 2013), the ultimate constraint on bank lending is neither reserves nor deposits which banks can attract. Instead, the real and significant constraint on bank lending, leaving aside demand-side factors, is bank capital. Importantly, de Boyer (1998), using both accounting and historical approaches, demonstrated that "[t]he recognition of the functions of bank shareholders' funds allows us to depart from the 'multiplier theory' and to reconsider the causal link between credit and deposit without failing in a 'pseudo chicken and the egg problem': do credits create deposits or do deposits create credits? In fact, the starting point is the contribution made by shareholders' funds [that is, bank capital]" (de Boyer, 1998, p. 62). This statement underlines the crucial importance of capital as a supply-side constraint on lending by banks. At the same time, it points to a good starting point of the discussion of the nexus between bank lending and the bank capital and liquidity.

Another crucial supply-side factor of bank lending is monetary policy of the central bank. Modern central banks that have adopted the inflation targeting as a monetary policy strategy, use the interest rate policy as a primary instrument to accomplish stipulated inflation targets. Conventional monetary policy that consists in setting interest rates in

[2] In addition, the demand for credit in theory depends (negatively) on the price of credit, i.e., lending rate, and (positively) on the inflation rate, as higher rate of inflation reduces the real interest rate *ceteris paribus*.

order to achieve the inflation target necessarily have to work through the financial system of the economy, and in particular through the banking sector. In this light, changes in the level of official interest rates as well as adjustments to large-scale asset purchase programs regarding the value and pace of asset purchases (known as the Quantitative Easing policy) inevitably produce important shocks to banks and thus can determine the volume and growth of their lending.

According to the literature review conducted in Chapter 1 and Chapter 2 of the present thesis, other potentially important supply-side determinants of bank loan growth includes bank-specific characteristics such as bank size, relative liquidity level, initial level of capital ratios; and country-specific variables such as degree of restrictiveness of capital regulations, stringency of overall restrictions imposed on banking activities and the market structure of European banking sectors.

The next part elaborates more on the link between bank lending and capital ratios, explicitly stating the research questions of the present thesis.

A research question concerning an actual form of the relationship between bank loans growth and capital ratio and the potential factors that may influence it, though now recognized as crucial (Kim and Sohn, 2017, p. 95), has been relatively neglected by financial researchers and experts in the field of banking and monetary analysis over the last decades. One of the fundamental factors that could change this relationship in recent years is unconventional monetary policy adopted by major central banks in the world, especially in the form known as Quantitative Easing (QE) policy.

With the availability of new and large data sets on banks and the banking practices (see Kashyap and Stein, 2000), and the occurrence of the global financial crisis of 2008, interest in the link between the amount of bank loans and bank capital (ratios) has increased and regained its deserving position on the research agendas across many leading academic and research institutions in the world.

The present dissertation identifies a research gap in the intersection area between two strands of the literature, namely finance and banking (the capital regulatory perspective) and central banking (the monetary policy perspective). In this light, understanding the relationship between bank lending and bank capital is an objective of immense significance. There exist at least three reasons why studying this phenomenon is important.

First of all, during the recent financial crisis, it was in a large part a shortage of bank capital that made banks and other financial institutions unable to extend more credit and grant new loans (cf. Gambacorta & Marques-Ibanez, 2011). Policy measures such as Troubled Asset Relief Program (TARP) in the US were explicitly designed to inject capital into banks through the Capital Purchase Program (CPP). The effectiveness of such programs, defined as the impact of a particular program on activities in the real sector of economy, largely depended on the postulated effect of these capital injections on bank lending growth[3] (Berrospide and Edge, 2010, p. 6).

Secondly, the transmission mechanism of monetary policy impulses was recognized to operate through the bank-capital channel which is fundamentally based on the investigated link between bank lending and capital – moderated by monetary policy shocks (see Kim and Sohn, 2017; Meh, 2011; Van den Heuvel, 2002). An importance of bank capital to the effective operation of monetary policy has been recently emphasized by Gambacorta & Shin (2018) who found that bank equity is a very important determinant of both the bank's level of funding cost and bank lending growth in Europe (Gambacorta & Shin, 2018, p. 17).

Thirdly, the direction of causation (or the lack thereof) in the examined relationship is important from the theoretical perspective, insofar as new competing theories have been put forward and the need of their verification has increased significantly. Two particular hypotheses that have emerged in the literature in recent years are 'financial fragility-crowding out' hypothesis and 'risk absorption' hypothesis (Berger and Bouwman, 2009, pp. 3786-88). Notably, the two hypotheses contradict each other as they postulate that the causality runs in the opposing directions (Kim and Sohn, 2017, p. 97).

Another crucial insight stemming from the research in this field is that bank-specific characteristics matter. Among the most important factors being bank's size, liquidity

[3] The political economy aspect might be of importance here. Too-big-to-fail banks may first take excessive risks (e.g., through subprime lending) and afterwards do not employ enough resources to monitor and restrict borrowers' adverse behavior. In this case, if a bank knew that it would always be 'recapitalized' or bailed out even in the worst-case scenario, the relationship between its lending activity and the capital level might actually be very weak. In the extreme case the two variables could be essentially 'decoupled', as a bank would (imprudently) grant loans regardless of the level of its equity capital. However, in the real world such hypothetical behavior has never been widely observed. In addition, the Basel Committee on Banking Supervision (BCBS) capital requirements aim precisely to curb such imprudent bank practices.

ratios, and initial level of a capital ratio (cf. Brei, Gambacorta, & von Peter, 2013; Kim & Sohn, 2017).

Importantly, the QE policy can also influence the investigated relation to a large extent. An examination of what factors determine the QE's impact on the relationship between the bank lending activities and bank capital ratios is the primary objective of the present dissertation[4]. Logically, it has to be done in two steps. Firstly, it should be established that QE policy is indeed a significant factor that affects the relationship between bank loans and capital. Subsequently, a range of potential factors that might change the QE's impact (i.e., variables that moderate it) must be empirically identified, studied and assessed.

The issue of appropriateness and effectiveness of Quantitative Easing policy has been largely covered in the literature related to the latter, nonetheless it leaves unanswered many questions and much research space within the field of the former. The impact of QE policy on an individual bank financial position and behavior is still a relatively unexplored research area. In general, however, the ongoing research within this field has brought some interesting findings in recent years[5].

The present thesis, therefore, tries to answer the question whether the European Central Bank's (ECB) Quantitative Easing (QE) policy has affected the relationship between bank loans growth and equity capital ratio (ECR) in Europe. The dissertation thus seeks to establish the determinants of the QE policy impact on the relationship between bank lending growth and equity capital ratio in the European banking sector. In other words, it investigates the conditions under which the unconventional monetary policy in the form of QE policy, such as ECB's Asset Purchase Program (APP), can be effective in strengthening (or weakening) the link between bank lending and bank capital ratios in Europe.

In order to achieve its research objective, the dissertation aims to answer the specific research question about the determinants of the QE policy impact on the relationship

[4] From the accounting view and a perspective of balance sheets, the QE policy can be regarded as a liquidity-improving tool in the unconventional monetary policy toolkit (Bezemer, 2010, 2016; Lavoie & Fiebiger, 2018). According to this view, the research objective of the present dissertation is closely related to the issue of 'liquidity impact' on the relationship between bank lending and capital – the phenomenon investigated in detail by Kim and Sohn (2017).

[5] These advances are discussed in literature review chapters of the present dissertation.

between bank lending growth and equity capital ratio in the European banking sector. Particularly, in relation to the sample used, there are five specific research questions investigated in this thesis:

1. Was the relationship between bank capital ratios and bank loans growth for European banks in the 2011-2018 period non-linear?
2. Was the sign in the relationship between bank capital ratios and bank loans growth for European banks in the 2011-2018 period in general positive?
3. Did the relationship between bank capital ratios and bank lending growth depend on a bank's size and specialization in the 2011-2018 period for European banks?
4. Did the relationship between bank capital ratios and bank lending growth depend on the bank's initial level of capitalization (that is, the initial capital-to-asset ratio) in the 2011-2018 period for European banks?
5. Did the relationship between bank capital ratios and bank lending depend on the bank's relative liquidity position expressed in its liquidity ratios in the 2011-2018 period for European banks?

The applied method of research is statistical and econometrical analysis of panel data. Using bank institution-level financial data, the dynamic fixed-effects model is estimated both in the baseline form with bank-specific variables and macroeconomic control variables, and in the extended form including crucial interaction terms that measure effects of capital, liquidity and the ECB's quantitative easing policy on bank loans growth.

Model diagnostics is based on results of the standard Durbin–Wu–Hausman (DWH) test, widely regarded as the Hausman (1978) specification test. In this panel-data procedure, both fixed effect and random effect estimates of coefficients are obtained and compared. The results of the Hausman test and other relevant statistics, such as results of the Breusch and Pagan's (1980) Lagrange multiplier (LM) test for random effects are assessed in order to determine the optimal model and estimator.

An empirical method applied in the research also consists in estimating and graphing panel data marginal effects that reflect a bank lending growth elasticity with respect to changes in a capital ratio. The marginal effects are juxtaposed for various bank category variables based on bank size, initial equity capital ratio, liquidity ratio, and two country-specific criteria for two groups of banks: those from QE-affected countries and other banks, proxied by an APP dummy variable.

Various data sources are used in the empirical part of the thesis. The main source of institution-level financial data on European banks is Bank Orbis Focus database. It provides a large bank-level financial dataset. The study uses annual observations on 3,494 active banks from Europe, spanning the period from 2011 to 2018 (inclusive). Data covers 54 European countries with the total of 27,952 observations. Such large sample size is due to the extensive cross-sectional dimension of the used dataset.

Other data sources include European Central Bank's Statistical Data Warehouse which provides data on QE-related variables. Country-specific and regulatory, i.e., micro and macro-prudential data for European countries come from various sources.

Source of information on micro-prudential indicators and on the capital adequacy standards restrictiveness is a large financial dataset created by Barth, Caprio, and Levine (2013) (henceforth BCL). The primary source of macroprudential regulations overall restrictiveness, and in particular of the international "Macroprudential Policy Index" is an extensive data set of Cerutti, Claessens, and Laeven (2015). Data on market structure and development, such as bank concentration indicator (based on bank total assets) and the share of government-owned banks in the banking system are derived from the BCL dataset for 2011. The data on banking market concentration is consistent with the World Bank's "Global Financial Development Database" (GFDD). Information on euro area membership is obtained from the European Commission. The source of the economic data on the real GDP and inflation is the World Bank's database "World Development Indicators" covering most of the countries in the sample. Data on the short-term rate of interest is the OECD's Financial data set. Eurostat is a source for data on long-term interest rate; and the Centre for Economic Policy Research is a source of data on the periods of recessions in the euro area.

In this thesis, the adopted definition of a capital ratio is as follows. A capital ratio is a simple accounting measure that reflects bank's financial health and soundness because it points to the amount of safe capital or equity, acting as a cushion or 'shock-absorber' against unexpected bank losses, in relation to the amount of risky financial assets that a bank holds on its balance sheet (cf. Farag, Harland, & Nixon, 2013). In order to increase the robustness of results, three different measures of a capital ratio are exploited. Two of them are regulatory risk-based ratios (as defined by the Basel Committee), that is the Tier 1 ratio and Total capital ratio measured as ratios of Tier 1 capital to risk-weighted assets (RWA) and Total capital to RWA, accordingly. A third measure of a bank capital ratio is the ratio of equity capital to total assets (henceforth equity capital ratio or ECR). There are two important advantages of using the ECR, that is its high coverage in the data sample and its high usage in the relevant literature. In regard to the definition of the quantitative easing[6] policy pursued by the ECB and implemented by the Eurosystem[7], following the approach Pyka et al. (2016), three types of QE-type policies need to be distinguished. That is, first, (i) indirect quantitative easing; second, (ii) direct quantitative easing; and third, (iii) direct credit easing (Pyka et al., 2016, p. 89).

The ECB introduced different unconventional monetary policy measures[8]. First, operations that were focused solely on the provision of bank liquidity at long-term maturities involve the Longer-Term Refinancing Operations (LTROs) and Targeted Longer-Term Refinancing Operations (TLTROs). These policy operations can be classified under the *indirect quantitative easing* category. Second, programs that were specifically designed to ease credit conditions and make markets for particular securities more liquid, such as the Covered Bond Purchase Program (CBPP) or Securities Markets Program (SMP) can be classified as *direct credit easing* policy. Third, a major and widely discussed (later on also expanded) Asset Purchases Program (APP) was launched in October 2014 with monthly purchases starting in March 2015 with an average pace of between 15 to 80 billion euro per month[9]. The APP involved several other programs that

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[6] Prof. Richard Werner (1995) was arguably the one who originally coined the term 'quantitative easing' to merely underline that the Bank of Japan's policy should have aimed at increasing the aggregate quantity of (bank) credit provided to the real sector of the Japanese economy (Lyonnet & Werner, 2012, p. 96). This easing of monetary policy was subsequently termed 'quantitative easing' with rather less emphasis on the dynamics of the aggregate credit and more emphasis on the central bank large-scale financial assets purchases that heightened commercial banks' reserves to the unprecedented levels. The Bank of Japan first adopted this policy during the 2001-2006 period, explicitly targeting some specific level of bank reserves. However, Borio and Disyatat (2009) actually consider it to be 'bank reserves policy' (Borio and Disyatat, 2009, p. 9).

[7] The Eurosystem comprises the European Central Bank (ECB) and the National Central Banks (NCBs) of those countries that adopted the euro as a single currency.

[8] For more details, see a review of the unconventional ECB's open market operations and non-standard monetary policy measures on the ECB's official site: https://www.ecb.europa.eu/mopo/implement/omo/html/index.en.html.

[9] See more information and statistics: https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html

were designed to facilitate purchases of specifically stipulated categories of financial assets[10]. The APP and its subprograms can be classified as *direct quantitative easing* policy. In this dissertation, the quantitative easing (QE) policy is defined as any unconventional monetary policy measure or instrument that belongs to the last-mentioned category.

The rest of this thesis is structured as follows. It consists of the introduction, four main chapters and the conclusions.

In Chapter 1, I describe the role and functions that banking organizations fulfill in modern economies. Thereafter, main determinants of bank lending in the economic theory are presented. The demand-side determinants are only briefly discussed since they do not constitute the central focus of the present dissertation. Because, as argued by Olszak (2015), bank lending appears to be highly procyclical, in Section 1.2 I focus on the supply-side determinants that can theoretically cause this lending procyclicality, such as bank profits and costs of credit intermediation. Section 1.3 elaborates more on the theoretical background on the link between capital ratios and bank lending. Consistent with the financial accelerator theory developed in the seminal works of Bernanke & Gertler (1995) and Bernanke, Gertler, & Gilchrist (1996), the original framework of bank capital and credit relationship (called a 'circular pyramid') is presented. Section 1.4 reviews the empirical evidence on the effects of the capital ratio on lending. The last section of Chapter 1 provides a summary of key empirical findings of the relevant literature that enables me to develop empirically testable research questions.

Chapter 2 focuses on the monetary policy transmission channels. Section 2.2 presents the taxonomy of both conventional and unconventional monetary policy measures based on Borio & Zabai (2016). Subsequently, I propose and discuss the original general framework of the monetary transmission mechanism based on *inter alia* Beyer et al. (2017) and ECB (2011). Accordingly, the propagation channels and the effects related to a standard (conventional) monetary policy in the form of interest-rate impulse and a non-standard monetary policy in the form of balance sheet policies'

[10] Importantly, the present thesis examines specifically the ECB's Asset Purchase Program (APP) that includes the following four programs: Corporate Sector Purchase Program (CSPP), Public Sector Purchase Program (PSPP), Asset-Backed Securities Purchase Program (ABSPP), third Covered Bond Purchase Program (CBPP3).

adjustments are theoretically reviewed and carefully analyzed. In Section 2.3, the monetary policy's credit channel that encompasses the bank lending channel, the balance sheet channel and the bank capital channel is discussed at length. A particular emphasis is put on two related effects that are regarded crucially important within the credit channel, namely the risk-taking and portfolio-rebalancing effects. Section 2.5 describes the empirical evidence on unconventional monetary policy effects on bank lending. A summary of theoretical monetary policy channels and the empirical hypotheses are provided in Section 2.6.

Chapter 3 describes the empirical method, data sources, initial data treatment, and econometric models that constitute a basis for the empirical analysis of the present thesis. In Section 3.1, the within-groups and between fixed effects estimators as well as random effects and hybrid models are presented in order to demonstrate how to deal with panel data problems such as the presence of unobserved heterogeneity, and the resulting omitted variable bias. Thereafter, data sources and definitions of variables are provided. Section 3.3 shows the initial data treatment which involves constructing bank-specific and country-specific categories; management of data outliers and identifying and dealing with mergers and acquisitions. In Section 3.4, a preliminary statistical and graphical analysis of the data is conducted on the final unconsolidated data sample. The results support the view of high heterogeneity among banks with regard to their size. The preliminary analysis confirms that the growth of loans supplied by small banks has been on average more volatile in comparison to large and medium-sized banks. Furthermore, a median small bank held on average 4.39 percentage points higher equity capital ratio than a median large bank in the 2012-2018 period.

In Chapter 4, I describe and interpret the main research results. The panel data regression analysis with a robust fixed effects estimator is employed to identify the determinants of the impact of quantitative easing policy of the ECB on the link between bank loans growth and the key capital ratios in Europe. Additionally, in Section 4.1 I describe expected signs and state basic arguments about the relationship between main regressors and the dependent variable. Last parts of Section 4.1 and Section 4.2 are devoted to diagnostics of the baseline and interactive models, respectively, using among others the Durbin–Wu–Hausman (DWH) test. Obtained results are checked for robustness with a use of the sensitivity analysis of the results of the estimation of the interactive model with an alternative liquidity ratio. Furthermore, the regression analysis of both baseline and interactive models is performed on the consolidated financial data in two subsamples of large banks and commercial banks. Chapter 4 concludes with a discussion of the research findings, linking them to the relevant literature, and pointing at some important study limitations.

The concluding part of the thesis summarizes the main findings, draws a number of policy implications and indicates directions for future research. In the thesis, five research questions have been answered. That is, all research questions have received a positive answer, except for Research question 2 which receives a conditional answer. The link between bank loans growth and capital ratios is found to be complicated and non-linear in its nature. This finding is in line with results obtained in a number of previous studies such as Beatty & Liao (2011), Brei et al. (2013), Carlson et al. (2013), Casu et al. (2018), Kim & Sohn (2017), and Olszak et al. (2016).

The results of the present thesis show that in the 2011-2018 period the said relationship significantly depended on a number of bank-specific characteristics: the bank size and specialization, bank's initial level of capitalization, and bank liquidity ratios. Consistent with the results of studies such as Kim & Sohn (2017) and Thornton & Tommaso (2020), but in contrast to the findings of Roulet (2018), estimated marginal effects in the interactive models indicate that in the case of regulatory ratios (Tier 1 ratio and Total capital ratio) the examined relationship was positive for sufficiently liquid banks. However, said link in the case of equity capital ratio was negative regardless of the level of bank liquidity. This finding implies that efforts of regulators and macroprudential policymakers are effective in constraining bank lending only when they impose restrictions on banks in reference to the capital adequacy requirements set by the Basel Committee.

The empirical evidence suggests that quantitative easing policy in Europe has indeed been successful in making banks more responsive to capital ratios in their lending. The QE policy of the ECB has effectively contributed to removing a liquidity constraint for less liquid banks, but on the other hand, it has made them less resilient (i.e., more responsive) to capital shocks. In this light policy actions should be aimed both at improving bank liquidity ratios (by means of the QE-style central bank balance sheet policies) and simultaneously at providing banks with resources to strengthen their capital ratios by official state-contingent capital injections or bank equity purchases programs. This reinforces the conclusions of Thornton & Tommaso (2020) that bank capital and liquidity position are complementary, mutually depended and both are crucially important for European banks to sustain the growth of bank credit.

Regulators and bank supervisors in order to prevent the build-up of imbalances in the economy should constantly monitor the level of bank capitalization, both at the individual and system-wide level. As the results of the present thesis show, any adverse capital shocks can be swiftly propagated to the real economy via a severe decline in bank credit. A sudden drop in bank lending (i.e., credit crunch) is in turn likely to cause a slowdown of economic growth. In addition, the results show that proposed state-contingent official capital injections or bank equity purchases programs should focus on providing additional bank equity especially for banks with low and medium level of capital ratios. Moreover, the ECB’s QE policy is found to be the most effective in strengthening the link between capital ratios and lending growth when applied to small banks experiencing liquidity problems.

Findings obtained in the present thesis will allow researchers, bank supervisors and policymakers to better understand the consequences of the ECB’s large-scale asset purchase program for lending and capital situation of individual banks in Europe. This, in turn, can contribute to designing better informed monetary and macroprudential policies and bank regulations.

Chapter 1. Capital as a determinant of bank lending

1.1 Role of banking organizations

Banking can be understood as a set of operations encompassing a broad scope of vital activities and functions that are performed by modern banking organizations. The particular definition of a bank is often based on what banks do and what according to law only banks can do. As a result, the definition of a bank is country-specific as it must be a legal definition that is used by regulators. In most countries, however, it is probably a very similar definition, and which is as follows: "a bank is an institution whose current operations consist in granting loans and receiving deposits from the public" (Freixas and Rochet, 2008, p. 1).

Authors usually emphasize three crucial roles of banks. Recently, it is often practice to add the fourth one that is connected to the modern economy's information environment and to the theory of asymmetric information. Firstly, banks provide payments services and infrastructure that is necessary to ensure a proper functioning of the settlements and clearing systems. It refers to banks settling transactions with each other on behalf of their customers (i.e., mostly depositors). The second role of banks is to provide credit to firms and households. For example, they give long-term loans to companies and provide mortgages to households. Banks refinance their new and existing lending with various sources of funding, mainly short-term bank deposits. Thus, they engage in the process of 'maturity transformation' by lending long and borrowing on a short notice. Moreover, by taking on credit risks of various types of borrowers, they contribute to the (credit) risk diversification in the economy. Thirdly, as financial institutions, banks provide a broad scope of other financial services that help households and businesses manage the various risks they face. This economic role consists in offering to banks' customers (often investors or other financial institutions) different kind of insurance or hedging products, such as financial derivatives, structured products, and securitized instruments.

The most recently exposed role of banking organizations is information processing and reducing information asymmetry and transaction costs. This role revolves around collecting data, screening, monitoring and auditing borrowers, wherein at each stage of these processes a bank engages in some kind of information gathering and processing. This fourth role can hardly be overstated.

As argued by Mishkin (1992, 1994), banks possess unique advantage in solving adverse selection and moral hazard problems that are inherently present in the credit market. By diversification within an intermediary, as demonstrated by Diamond (1984), they can significantly lower transaction costs of monitoring behavior of their borrowers, compared to direct lending. Thus, banks can be viewed as a delegated-monitoring device helping to mitigate adverse effects of an *ex-post* information asymmetry (i.e., moral hazard) that occurs whenever borrowers find economic incentives to default on their debt (Diamond, 1984, p. 393). Furthermore, banks have a natural advantage in collecting information and reducing moral hazard because they establish long-term relationships with their customers (Mishkin, 1994, p. 7).

This last role of establishing and keeping on the ongoing basis a long-term relationship with customers (especially borrowers, and to a lesser degree with depositors) was early recognized by Schumpeter in his *Business Cycles* in which he underlined that:

> "(…) the banker must not only know what the transaction in which he is asked to finance and how it is likely to turn out, but he must also know the customer, his business, and even his private habits, and get, by frequently 'talking things over him', a clear picture of the situation" (Schumpeter, 1939, p. 116).

In this light, the function of banking organizations as a delegated monitor focuses not only on reducing borrowers' incentives to misbehave (that stems from an *ex-post* information asymmetry) but also, and perhaps crucially, on understanding the business model and daily operations of borrowers. The latter is also required in the situation of an *ex-ante* information asymmetry (i.e. before a financial contract has been agreed upon) where a bank has to screen potential borrowers in order to reduce the probability of adverse selection. Screening basically helps to decide whether a specific investment project is indeed profitable, and thus, if a potential borrower is creditworthy and will pay off his debt.

1.2 Determinants of lending in the economic theory

In this section, first, some demand-side determinants of lending are briefly reviewed. Thereafter, using a simplified balance sheet of a commercial bank and a derivation of the bank profit equation some specific supply-side determinants of lending are presented. Finally, in line with the asymmetric-information view and with the financial accelerator theory, the procyclicality of bank profits is theoretically demonstrated to hold.

In the literature there is a broad consensus that bank credit due to, *inter alia*, marked-to-market accounting and leverage, is highly procyclical. In normal periods (in contrast to recessionary periods) credit is indeed predominantly demand-determined and endogenously created, as banks tend to accommodate to a large extent the demand for credit, satisfying financial needs of a growing economy[11]. The demand-side factors are related to aggregate (mostly macroeconomic) business cycle variables, such as GDP growth, employment rate, investment and consumption growth, real wages, etc. In the present dissertation, while demand-side factors are considered, they do not, however, constitute the main point of its focus.

The principal supply-side determinant of bank lending is bank profitability. Drivers of the profitability of a bank are multiple and the intensity of the involved factors can vary, as they are mainly bank-specific. Nevertheless, one can still analyze a typical bank's balance sheet and bank's profit equations using a general framework. In order to gain a better understanding of the process, a simple stylized model of bank lending business will be used. Firstly, bank's balance sheet identity, in any time showing a snapshot of bank's financial position, must be considered for any theoretical discussion and practical purposes. Figure 1.1. presents a simplified balance sheet of a typical commercial bank.

Figure 1.1. Simplified balance sheet of a commercial bank

Commercial bank	
Assets	*Liabilities*
Reserves (R)	Interbank Borrowing (IB)
Loans (L)	Deposits (D)

[11] For further discussion on this point see, for example, Adrian & Shin (2010), Bachurewicz (2019), and Olszak (2015).

Securities (S)	Shareholder Equity (E)

Source: own elaboration.

On the asset side, a bank's reserves (R) in this simplified model include both cash reserves and liquid balances held at its account with the central bank. The second item is loans to private sector (L) to households and companies, and the third is marketable securities (S) – mostly in the form of safe government bills and bonds. On the liability side, as is shown in Figure 1.1, banks fund themselves with interbank deposits (IB), i.e. mainly with short-term wholesale borrowing from other banks. Secondly, they also refinance they lending operations with many retail deposits (D) from the public. The third source of bank's funding is bank capital, which is in this simple model, the shareholders' equity (E) that consists of the shares issued (if the bank is listed on the stock market), or more generally, this position consists of the Basel's Pillar 1 minimum capital requirements in the form of Common Equity Tier 1 capital (CET1).

Firstly, the balance-sheet identity which states that total assets equal total liabilities including shareholder equity ($A = L$) must be always satisfied:

$$R + L + S = IB + D + E \tag{1.1}$$

In the traditional banking business model, banks make profits through their lending activity. Banks earn profits essentially by charging a higher (expected) loan rate (r_L) than the (weighted average) rate they have to pay out on their sources of funding (i.e., bank's weighted average cost of capital, WACC) which traditionally mainly depends on the rate on retail deposits (r_D). In a general case, the expected loan rate (r_L) is different from the contracted loan rate (r_C) because some of the bank's borrowers will default on their loan. Assuming that the average expected probability of default equals θ, and that the recovery rate is γ which can be thought of as $1 - LGD$ (loss given default), one can calculate the expected rate on loan as:

$$r_L = E(1 + r_C) - 1 = (1 - \theta) \cdot (1 + r_C) + \theta \cdot \gamma \cdot (1 + r_C) - 1 \tag{1.2}$$

Using the balance sheet positions presented in Figure 1.1, one can calculate the bank's weighted average cost of capital (r_{WACC}) as:

$$r_{WACC} = \frac{IB}{A} \cdot (1 + r_{IB}) + \frac{D}{A} \cdot (1 + r_D) + \frac{E}{A} \cdot (1 + r_E) - 1 \tag{1.3}$$

Thus, in this simple model, a bank makes a profit (π) whenever the expected loan rate is higher than the bank's cost of capital ($r_L > r_{WACC}$). To be more precise, it can be assumed that a bank faces some fixed costs of C and the variable costs related to screening, monitoring, and enforcing meeting contractual obligations of borrowers which one can all put in the broad category of cost of credit intermediation[12] (CCI). Furthermore, I assume that another cost category are loan loss provisions which equal *LLPs*, and that the risk-free rate on the marketable securities held by banks equal r_F, and that bank's reserves (including cash) held at the central bank are unremunerated. Under these assumptions the bank's interest margin is given by:

$$\pi = L \cdot r_L + S \cdot r_F - D \cdot r_D - IB \cdot r_{IB} - E \cdot r_E - C - CCI - LLPs \tag{1.4}$$

Substituting r_L from Equation 1.4 with the expected loan rate from 1.2, produces the following bank profit equation[13]:

$$\begin{aligned} \pi = L \cdot [(1 - \theta) \cdot (1 + r_C) + \theta \cdot \gamma \cdot (1 + r_C) - 1] + S \cdot r_F - D \cdot r_D - IB \cdot r_{IB} \\ - E \cdot r_E - C - CCI - LLPs \end{aligned} \tag{1.5}$$

Importantly, Equation 1.5 clearly predicts that especially in the recessionary periods bank profitability is severely reduced since:

i. borrowers' average default rate (θ) increases sharply during recessions;
ii. the recovery rate (γ) significantly lowers as the market value of the pledged collateral erodes, and the market value of real-estate, housing, and most of financial assets declines considerably as well;
iii. interbank borrowing rates (r_{IB}) may peak due to a liquidity squeeze in the interbank market;
iv. cost of issuing new equity (r_E) increases as the stock market prices decline and due to negative signaling concerns that worsen investors' expectations and lead to a decrease in the demand;

[12] I define a bank's cost of credit intermediation, following Bernanke (1983), as a theoretical (and not accounting) category of bank costs that includes: "screening, monitoring, and accounting costs, as well as the expected losses inflicted by bad borrowers" (Bernanke, 1983, p. 263).
[13] It is worth noticing that in the presented model both in the WACC equation 1.3 and in the profit equations 1.4 and 1.5 the assumption is that there is no corporate (bank income) tax.

v. cost of credit intermediation (CCI) soars as banks have to commit more financial resources on the necessary activities (such as, screening, monitoring, and debt contract enforcement) that allows them to mitigate the severely increased *ex-ante* and *ex-post* asymmetric information problems;

vi. banks are forced to increase the amount of loan loss provisions (LLPs) as they anticipate more defaults on the previously granted credit and loans.

The predictions of the above model of the procyclicality of bank profits is in line with much of the empirical evidence that will be presented in the next sections of this Chapter 1. Theoretically, the procyclicality of bank profits is consistent in particular with the broader strand of literature that focuses on the financial accelerator hypothesis put forward, most notably, in the seminal works of Bernanke & Gertler (1995) and of Bernanke, Gertler, & Gilchrist (1996).

As Bernanke (2007) pointed out, "(…) the financial accelerator seems intuitive – certainly financial and credit conditions tend to be procyclical (…)." By amplifying an initial negative shock, often emerging from the real-side of the economy, the financial sector tends to operate as an amplifier that causes a vicious circle with mutually increasing feedbacks of financial losses. Fundamentally, the amplification process is as follows: higher probability of credit default and lower profitability of lending to businesses cause banks to reduce lending during recessions, and thus negatively affecting the real side of the economy that, in turn, worsens bank profits even further. This mechanism provides a prime example of the vicious circle. In short, more credit defaults in the economy lowers profitability of lending causing reduced amount of credit extended to the economy that, in turn, triggers even more defaults and even greater losses for banks and so forth.

Bernanke et al. (1996) interpreted this mechanism as "(…) resulting from endogenous changes over the business cycle in the agency costs of lending," stating that "an implication of the [financial accelerator] theory is that, at the onset of a recession, borrowers facing high agency costs should receive a relatively lower share of credit extended (the flight to quality) and hence should account for a proportionally greater part of the decline in economic activity" (Bernanke et al., 1996, p. 1). In line with this view, the procyclicality of bank profits, which stems predominantly from asymmetric-information related costs and a high credit default rate in downturns (leading to a higher

CCI and consequently higher LLPs), inevitably, is the main driver of bank lending, also in this way rendering it a procyclical economic phenomenon.

1.3 Theoretical background on the link between lending and capital ratio

In light of growing empirical evidence of the importance of bank capital position and capital ratios for banks to provide new loans many economists have in the last three decades investigated this link more closely (cf. Gambacorta & Shin, 2018).

This heighted research interest, however, had not always been so strong in the past because, as Friedman (1991) observed, "[t]raditionally, most economists have regarded the fact that banks hold capital as at best a macroeconomic irrelevance and at worst a pedagogical inconvenience. The presence of a capital account, rendering bank assets not equal to bank liabilities, adds unwelcome complexity to the otherwise analytically neat story (…)" (Friedman, 1991, p. 240). In his comment to Bernanke & Lown (1991) article on the so-called 'credit crunch', Friedman (1991) went on to suggest that in the presence of both minimum reserve requirements and minimum capital requirements, banks in their lending business might be more restricted by the latter requirement than by the former[14].

Today, with a hindsight, it is widely recognized that Friedman's (1991) speculation was valid. Especially in the post-crisis period the minimum capital requirements are far more binding due to monetary policy unconventional measures adopted by central banks that led to a massive growth in the bank reserve positions in many developed countries. More generally, however, one can conclude that during a financial crisis both the liquidity and capital position become a binding constraint on bank lending, and thus are both its important determinant (Van den Heuvel, 2002, p. 260).

There are multiple reasons why bank lending might be actually capital-constrained, rather than reserves-constrained. Firstly, banks do not simply act like other financial intermediaries lending out their reserves that they can beforehand obtain from the central bank or from other monetary institutions (i.e., banks), and neither they are lending out deposits they can obtain in advance from their customers. This proposition, though

[14] It is worth noticing that in 1988 the Basel Committee on Banking Supervision (BCBS) in Basel published a set of minimum capital requirements for banks from ten most developed countries (the G-10 group). This has come to be known as the 1988 Basel Accord or simply the Basel I accord.

elementary as it seems, is of crucial importance. Banks do not lend out their reserves or deposits because there is no accounting procedure or technique that would allow them to do so (see, on this subject, among others, Bachurewicz, 2019; Borio & Disyatat, 2009; Jakab & Kumhof, 2015; McLeay, Radia, & Thomas, 2014; Sheard, 2013).

Secondly, the central bank should in any case endogenously accommodate all the demand that there is for any amount of reserves that banks need. Failing to provide reserves on demand would raise concerns about central bank abandoning its major goal of securing the financial stability. It is widely acknowledged that the central bank has to safeguard the smooth functioning of both payment system and the interbank overnight deposit (i.e., reserves) market, that is, to maintain the target level of overnight policy rate to fulfill its role as a lender of last resort.

Thirdly, unlike bank capital there exists interbank market for reserves in which all the reserves-constrained banks can borrow additional reserves from the banks with a surplus of reserves (excess reserves). Furthermore, in the case of the so-called market liquidity squeeze, that is, in the situation in which banks do not want to lend to each other in the interbank liquidity market, they can always obtain the additional liquidity either via a repo (secured) transaction with the central bank or through borrowing directly from the central bank using a discount window (which in Europe is called a marginal lending facility).

Fourthly, as already mentioned, there is no interbank market for bank capital equity. Banks, facing heavy losses, shrinking profits and falling capital position, may desire to begin selling other presumably risky assets in order to maintain the required minimum capital ratios, and thus fulfill the capital requirements. In such situation, banks may well decide to fire sell assets and also stop new lending as the process of issuing new common equity is expensive and time-intensive. Especially during the crisis periods, when the stock market prices decline, it may be relatively very costly for banks to raise new capital (by new equity issuance) for three reasons. First, they will get a lower price than they otherwise would get in more tranquil periods. Second, this decision may have some unintended consequences such as a dilution of the stakes of the existing bank's owners (i.e. shareholders). Finally, it may require a long time to arrange a new shares issuance since the bank's senior management must usually beforehand obtain the approval of this decision from the board and from major shareholders. (see Mora & Logan, 2012, for further discussion of some implications of the absence of the interbank market for bank capital).

It is worthwhile to discuss the role and nature of bank capital and the primary functions that it serves. In most basic terms, bank (equity) capital is a residual term, i.e. the difference between the value of bank total assets and total liabilities or, in other words, the net worth of a bank[15] (for details see Figure 1.1 that presents a stylized bank's balance sheet in Section 1.2). Bank capital, which can be considered as a bank's own funds (rather than borrowed funds or wholesale or retail deposits), is the permanent (e.g., common share) source of funding that is designed to absorb loan losses and accumulate bank's retained earnings while it remains a 'going concern'. A bank is a going concern, to use a regulatory phrase, as long as its total assets position exceeds the value of total liabilities. In other words, as long as it remains balance sheet solvent. In downturns, as a troubled bank can incur more and more heavy losses its total capital position may become entirely depleted, in which case it will not have enough assets to repay its liabilities to borrowers (a situation of balance sheet insolvency). Thus – while the liquidity risk, i.e. a risk that a bank does not possess sufficient amount of liquid assets (in the form of cash or central bank reserves) or collateral to make current payments to its customers as they fall due (a situation of cash-flow insolvency), remains a valid concern for a bank – it is the bank's capital (suffering from the credit risk materialized in loan losses) that matters for its ultimate solvency and so for its economic survival[16].

It is now worth moving on to the core theoretical question of how the actual relationship between bank capital ratios and lending might in theory look like. The direction, strength and possible (non-)linearity of the causation (or lack thereof) in the examined relation is important from the theoretical perspective, insofar as new and conflicting theories have been put forward and the verification need on the side of policymakers and central bankers themselves has also increased vastly.

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[15] Total liabilities in this definition mean bank's borrowed funds and do not include net worth or bank equity capital.

[16] An extreme example of the distinction and inherent mutual entanglement between liquidity-induced problems (default risk) and credit-risk-induced problems (insolvency risk) has been observed during the crisis of 2007-8 (GFC), especially by a collapse of an investment bank Lehman Brothers that was forced to a bankruptcy as a result of the combination of the two, in the absence of government bailout or a guarantee of such a bailout. For further discussion of this case, see Brunnermeier (2008).

A link between bank lending and capital ratios has been a central focus of many empirical studies. However, only a few of them try to develop a coherent and general theory that could fully explain this relationship. For example, Kim and Sohn (2017), who examined the liquidity effects on the link between bank loans growth and capital ratio, conclude that “bank capital and lending exhibit a complicated relationship rather than a linear relationship” (Kim & Sohn, 2017, p. 106). In next paragraphs, I will review further this strand of literature while discussing arguments and evidence for and against this ‘non-linearity hypothesis’ that refers to the link between bank capital and lending.

First of all, a vast majority of empirical literature that pointed to the likely non-linear relationship between bank capital (ratio) and lending, has appeared as a response to the so-called ‘credit crunch’ hypothesis put forward by Bernanke & Lown (1991) in the context of the 1990-1991 recession in the US. Research on this phenomenon has led to a new term of ‘capital crunch’ in relation to the situation of banks being unable to provide credit to the economy due to capital regulatory constraints in the face of severe loan losses (see more on this in Van den Heuvel, 2002). For example, Syron (1991), who wrote during the midst of the 1990-1991 recession, concluded that a substantial decrease in the bank capital position had led to severe problems that affected heterogeneously different banks in the US. Specifically, he argued that:

> “Our current credit problems are not the result of a drain of bank deposits, to be ended by lower interest rates. In substantial measure this period of tight credit is the result of a loss of bank capital, rather than a loss of deposits. The shrinking availability of credit from banks thus may be more accurately characterized as a capital crunch rather than a credit crunch. This capital crunch has been uneven in its effects on our depository institutions” (Syron, 1991, p. 4).

To sum up the findings of studies that investigated the 1990-1991 and other recessions, Van den Heuvel (2002) succinctly stated that “[r]esearch on this and other episodes has found that low bank capital is associated with sluggish lending” which would suggest a positive link between the two studied variables. However, he also pointed out to a relative scant body of research that had focused on “the role of bank capital and capital requirements in the monetary transmission mechanism” (Van den Heuvel, 2002, p. 259).

Investigating this field is, broadly speaking, one of the objectives of the present dissertation.

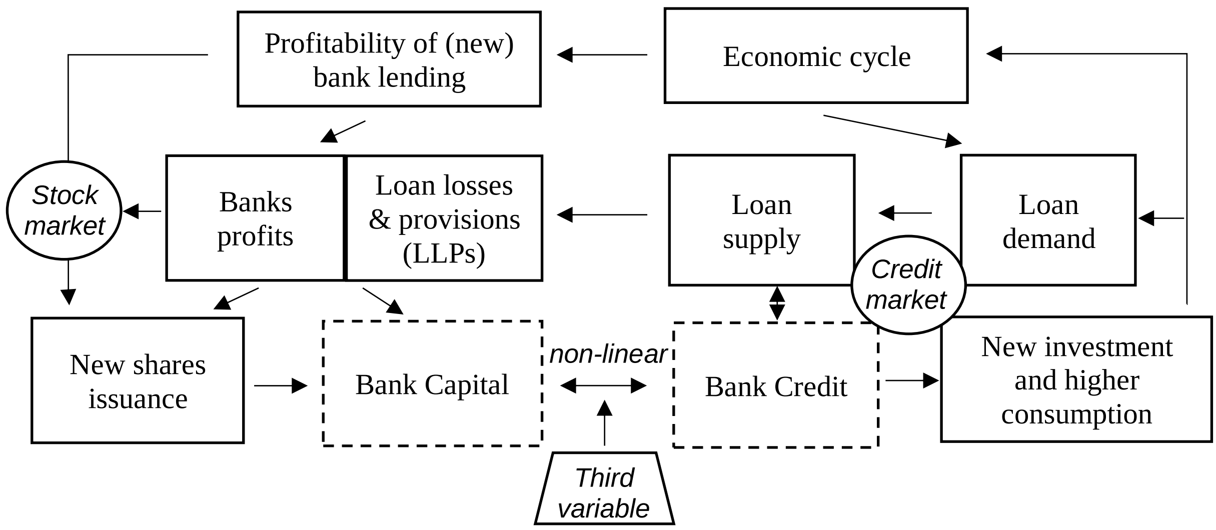
In general, many authors encountered significant difficulties in determining the link between bank capital and lending, owing to a large number of factors that are involved in this relation, and undoubtedly, can affect it in a statistically and economically significant way (see also Sharpe, 1995 and Van den Heuvel, 2002). In this view, the most challenging theoretical difficulty consists in disentangling the supply and demand factors that both contribute to the level and growth of bank lending. This important challenge, as strongly emphasized by Sharpe (1995, pp. 2 and 10) and Van den Heuvel (2002, p. 264), represents a fundamental identification problem both from the theoretical and empirical, i.e. statistical and econometrical perspective[17]. Particularly, Sharpe (1995) in his analysis of the studies and their findings related to the credit (capital) crunch hypothesis, reached the following conclusion:

> "It is difficult to discern the degree to which this relationship between bank loan growth and earnings (or loan losses) reflected (i) the latter variable's direct effect on bank equity versus (ii) its role as a signal of bank prospects for profitable lending – loan demand by creditworthy borrowers. If, to a substantial degree it reflected the direct capital effect, then losses to equity capital can account for a great deal of the variation in loan growth across banks" (Sharpe, 1995, p. 2).

Based on this theoretical account, I propose a stylized framework of bank capital and credit, which relates to the previous studies and highlights the most important causal relationships. It is shown in Figure 1.2 It must be stressed, however, that (i) it is a simplified theoretical framework that will be useful in other parts of this dissertation; (ii) these causal relations in the real world might be quite different depending on a specific country and a specific bank that is considered; (iii) the arrows denoting (theoretical) cause-and-effect relationships might not necessarily run only in one direction but may be in fact bidirectional.

[17] In the words of the latter author referring to the conclusions reached by the former, "the research has been less successful in determining whether this association is due to a causal effect of bank capital on loan supply because of the difficulty in distinguishing between loan demand and loan supply" (Van den Heuvel, 2002, p. 264).

Figure 1.2. Stylized framework of bank capital and credit relationship: a 'circular pyramid'



Source: own elaboration.
Notes: arrows denote theoretical causality running in the direction indicated by an arrow.

A circular pyramid of causal relations that form the environment of bank capital and credit relationship refers not only to demand-side factors (such as, economic cycle and investment and consumption expenditures) but also to concepts introduced in Section 1.1 which discusses determinants of lending in the economic theory. In particular, the stylized framework presented in Figure 1.2 accentuates: the credit and stock market presence and importance (as both of them are a source of asymmetric information problems); the main driver of bank lending which is bank profitability (which itself is procyclical), and costs of non-performing loans that a bank must bear, which prompt banks to make loan loss provisions or LLPs, that in turn, lower its profit and thus make it more costly to raise new capital in the stock market.

Let me now reflect upon the circular pyramid framework presented in Figure 1.2 from the particular perspectives of the asymmetric-information, financial-accelerator, and endogenous-money theories. The proposed circular, general framework appears to help more clearly see and understand the dynamics of the examined relationships from all three theoretical approaches.

First, the asymmetry of information in the context of the link between bank capital and lending is present on two tiers. In the credit market (marked in Figure 2 in a circle on the right-hand side), as was already explained in Section 1.2, banks fulfilling their primary functions as lenders, screening devices, and delegated monitors encounter typical principal-agent problems and the famous ‘lemon’s problem’ (Akerlof, 1970; Bernanke, 1983; Stiglitz & Weiss, 1981). This level of information asymmetry in the presented general framework one can call a first tier. In the stock market (marked in Figure 2 in a circle on the left-hand side), however, it is external investors, potential owners of a bank’s equity and existing shareholders of a bank that encounter the negative-selection problem which also stems from information asymmetry (Myers & Majluf, 1984). In this second tier, it is the external finance premium that is a cost to banks, as they seek borrowers in order to raise capital, for example, through an issuance of new shares. As Mora & Logan (2012) pointed out, the asymmetric-information problems at this level can be as severe as in the credit market since “[a]lthough information asymmetry between insiders and outsiders plagues all firms seeking outside finance, [bank assets] can be opaque and harder to value than those of nonfinancial firms” (Mora & Logan, 2012, p. 1104). In short, investors particularly in periods of economic turmoil simply cannot distinguish between healthy banks and balance sheet insolvent banks, especially since “[t]he value of bank assets […] hinges on the ability of bankers to overcome, in turn, asymmetric information problems with their borrowers” (Mora & Logan, 2012, p. 1104).

Second, considering the theoretical framework shown in Figure 1.2 from the broad, big picture perspective, one can see that it is not only consistent with asymmetric-information view, as has been argued above, but also with the financial-accelerator view which adds to the former view also demand-side considerations and feedback ‘accelerator’ effects (Bernanke et al., 1996; Bernanke, 2007).

Third, finally, the proposed general framework is broadly speaking also consistent with the endogenous theory of money and credit (Lavoie, 1992; Moore, 1988) which is associated with a post-Keynesian tradition (Bachurewicz, 2019). In a nutshell, the endogenous theory of (credit) money states that “the money stock is credit-driven and demand-determined” (Moore, 1989, p. 66), and that “[bank] loans make deposits instead of the reverse” (Bachurewicz, 2019, p. 404), which in the modern economy reflects the fact that the central bank provides high-powered money supply (that is, central bank reserves and cash) for banks on demand, thus accommodates fully the banks’ demand for reserves[18].

[18] On the other hand, the endogenous theory also states that commercial banks in normal times provides (new) credit to all creditworthy borrowers that are willing to borrow and have an adequate collateral (which a proposition that is termed a ‘horizontalist’ view on money endogeneity – for further discussions see

In regard to the crucial problem, which is marked by a trapezium at the bottom of Figure 1.2., namely the issue of non-linearity of bank credit and lending relationship, a question arises as to what exactly are the factors that account for this non-linearity in the examined relationship. Any significant factor, a 'third variable' or an 'omitted variable'[19] can exert an impact on the sign and strength of this relationship. It can moderate some of the causal relations in the environment of the examined relationship, or it can directly affect either the effects of bank capital on lending, or the effects of lending on bank capital, and thus can produce the net effect running in one or the other direction. A set of potential factors (third variables) stems directly from a review of empirical evidence and theoretical literature on this subject.

Firstly, a few authors who in the early 1990s studied the phenomenon of 'credit crunch' (or more accurately the 'capital crunch') during the recession, reached the conclusion that for banks that are less capitalized the minimum capital requirement must be a more binding constraint, and a result, one should observe the non-linear relationship between a bank's capital ratios and its lending. In other words, as a bank experience more and more credit losses that reduce its capital position (or experience a large increase in its risk weighted assets or RWAs) the relationship between bank's capital ratios and lending should become positive and stronger. In general, financially weak banks, which are close to the regulatory capital requirement might find themselves curtailing (new) lending especially to borrowers perceived as risky, and especially in the periods of heightened overall uncertainty (i.e. in a crisis or a recession). A quote from Friedman (1991) in the context of US 1990-91 recession, well demonstrates this point:

> "Brainard observed that one might expect the effects of capital requirements to be highly nonlinear, with changes in capital relatively unimportant for sound banks but very important for banks near insolvency. Allen Frankel thought this might explain why the coefficient on the capital-asset ratio in the linear equation does not do a good job of explaining the New England

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Palley, 2013; and Rochon & Rossi, 2013). Obviously, in the real world, a researcher must consider also all possible credit-rationing practices of banks that can happen primarily during market turbulences or in a situation of the credit market squeeze.

[19] These terms stem from the third-variable problem in psychology and the omitted-variable bias in econometrics, respectively.

> experience. The typical bank in New England is much closer than the average bank to a regulatory problem" (Friedman, 1991, p. 246).

These non-linearities in the relationship between bank capital and supplied lending that "arise as banks worry more about regulatory thresholds as they become close to being binding" (Carlson, Shan, & Warusawitharana, 2013, p. 679) has also been empirically shown in a number of recent studies including, *inter alia*, Brei, Gambacorta, & von Peter (2013); Carlson et al. (2013); Kashyap & Stein (2000); Kim & Sohn (2017); Kishan & Opiela (2000); and Olszak, Pipień, & Roszkowska (2016). It is important to emphasize that a majority of these studies point to cross-sectional factors (e.g., bank-specific variables such as, *inter alia*, bank size, bank's liquidity position, the initial capitalization) that to a large extent affect the examined relationship[20].

From the liquidity-providing perspective, as presented for instance in Kim & Sohn (2017), the above lines of reasoning are consistent in particular with the so-called 'risk absorption' hypothesis put forward recently in Berger and Bouwman (2009). These researchers, studying the link between bank capital and bank liquidity creation, proposed two broad sets of theories: the 'financial fragility-crowding out' and the 'risk absorption' (Berger and Bouwman, 2009, p. 3783). Notably, the two hypotheses contradict each other as they postulate that each causality runs in opposing direction[21] (Kim and Sohn, 2017, p. 97). Kim & Sohn (2017) emphasize the distinction between the two effects by stating that:

> "The 'financial fragility crowding out' hypothesis predicts that the effect of bank capital on lending is negative because, unlike depositors, capital investors who cannot run on the bank are reluctant to provide loans. Thus, banks with a higher capital ratio might supply fewer loans by crowding out deposits. Conversely, the effect of bank capital on lending is positive under the 'risk absorption' theory because bank capital enhances banks' risk-bearing capacity" (Kim & Sohn, 2017, p. 97).

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[20] The empirical and quantitative findings of these studies remain a subject of Section 1.4 of the present dissertation.

[21] In this section, I limit the theoretical discussion to the general phenomena leaving the review of empirical evidence of the effects of bank-specific characteristics (*inter alia*, bank's size, liquidity ratios, and initial level of capitalization) for the next Section 1.4.

Kim & Sohn (2017) concurrently seem to acknowledge the fact that the above conclusion is more a conditional proposition than a pure contradiction. They suggest that a sign of the bank capital ratio and lending is contingent on the bank's liquidity position. They indicate that it is, however, likely that "once banks accumulate sufficient liquid assets (…) capital investors become less reluctant to supply loans, and the increase in bank capital improves banks' risk-absorbing capacity significantly" (Kim and Sohn, 2017, p. 98). Adding to this by drawing from the arguments presented in previous paragraphs of this Section, it is important to recall that in current monetary framework the situation of a bank being capital-constrained is more likely to occur and undoubtedly more challenging than the situation in which a bank is liquidity-constrained in its lending. In the latter case, a bank can at relatively low cost obtain the additional liquidity from other commercial banks or from the central bank. The existence of the interbank market for (unsecured) reserves and interbank money markets in general (with for example, secured conditional instruments such as repo transactions) is a primary way to mitigate the liquidity problems. In contrast, an interbank market for bank capital is absent (Mora & Logan, 2012, p. 1104).

The second major factor that, in theory, can explain the non-linearity of bank capital (ratios) and lending relationship is dynamical (and usually procyclical) changes and fluctuations in bank's risk-taking, or in other words, variations in the dynamics of bank's risk appetite. Calem & Rob (1999) were the first researchers who, using a realistically calibrated model of a banking firm, discovered a specific U-shaped relationship between bank capital position and risk-taking. They summed up their findings by stating that:

> "A general implication of the model is that the amount of risk a bank undertakes depends on the bank's current capital position, where the relationship is roughly U-shaped. In particular, a severely under-capitalized bank tends to take on maximal risk. This result suggests that moral hazard is a serious problem among banks near to insolvency" (Calem & Rob, 1999, pp. 349-350).

As straightforward as it may seem, they found also that after an initial large increase in risk-taking in the case of poorly capitalized bank, it follows that the bank's risk appetite is diminishing as it gets better and better capitalized, and as a result the probability of its bankruptcy becomes smaller and smaller. In an essence, it implies that the relationship between a bank equity capital and risk-taking forms a U shape[22]. Moreover, the observed moral hazard behavior may be motivated by "[a] deposit insurance premium surcharge on undercapitalized banks [that] induces them to take more risk" (Calem & Rob, 1999, p. 317).

However, to link a banks' risk-taking decisions with their lending operations one must investigate more carefully banks' behaviors, especially in relation to their (loan) portfolio behaviors. Mora & Logan (2012) hypothesized that bank capital might be in fact endogenous to a bank's portfolio risk because, for example, banks with better growth prospects (and consequently, with greater lending opportunities) "are likely to hold more capital as a buffer because their earnings are also riskier" (Mora & Logan, 2012, p. 1113). This proposition was also put forward by Valencia (2008) who developed a model in which banks maintain a precautionary level of capital in order to smooth shocks that can disrupt their credit supply.

Finally, in a recent study of non-linearity in the relationship between bank capital and lending, Catalan, Hoffmaister, & Anggadewi Harun (2017) provided some more evidence that seem consistent with both the above-discussed 'precautionary motive' and with a discussed in the previous paragraphs 'capital threshold' view that accentuates the existence of non-linearity. In particular, they found that that in the light of the non-linearity of bank capital and lending relationship that implies the existence of some threshold level of capital ratio after exceeding which banks seem to curtail their lending, the important consideration for the transmission mechanism of bank capital shocks is not the aggregate level of bank capital *per se* but its distribution among banks as well as their initial level of capital. In relation to public economic policies, these authors logically concluded that "the impact of bank recapitalizations on loan growth will depend on the size of the capital injections as well as on the banking system's initial capital position" (Catalan et al., 2017, p. 6).

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[22] Importantly, the discovered bank behavior is not a macroeconomic, aggregate phenomenon, but is rather a purely micro-economically driven observation. As the authors excellently put it, "(…) severely undercapitalized banks as well as well-capitalized banks take more risk than banks with 'intermediate' capital position. The reasons for taking more risk, however, are different. The undercapitalized bank takes more risk because—in the event of bankruptcy – it shifts the cost to the FDIC (so its risky investments are 'subsidized.') The well-capitalized bank, on the other hand, chooses the risky investment because of its higher profitability (on average) and because the probability of bankruptcy is small" (Calem & Rob, 1999, p. 319).

Summing up these discussions, undoubtedly, one could observe in the post-crisis literature a growing focus on the relationship between bank capital ratio and its loans growth. Several studies provided both theoretical arguments and empirical evidence in favor of the proposition that this relationship is likely complicated and certainly not linear. For example, Carlson et al. (2013) showed "that the elasticity of bank lending with respect to capital ratios is higher when capital ratios are relatively low, suggesting that the effect of capital ratio on bank lending is nonlinear" (Carlson et al., 2013, p. 663). This evidence of the non-linearity is further reinforce by the post-crisis "rescue packages" literature such as in Brei et al. (2013) and Valencia (2008). For example, Brei et al. (2013) found that "[w]hile stronger capitalisation sustains loan growth in normal times, banks during a crisis can turn additional capital into greater lending only once their capitalisation exceeds a critical threshold" (Brei et al., 2013, p. 490).

All in all, the theoretical arguments and evidence reviewed in this Section point to a high probability that a relationship between bank capital ratio and loans growth is complicated and essentially non-linear. There might even exist a bidirectional causation between these two variables. While higher capital ratios tend to lead to an increase in lending, the heightened bank lending, on the other hand, tend to lower the capital ratios (either directly through an increase in RWA or indirectly through credit losses that leads to higher LLPs, lower profits, and eventually to an eroded capital level). In theory, this leads to a situation that can resemble a quasi-equilibrium. As a result, one can expect that much of the empirical evidence on sign and strength of the relationship can be mixed or conditional on some other (third) variable that can moderate one of these two effects, and thus can produce the net effect running in one or the other direction.

1.4 Empirical evidence on the effects of capital ratio on lending

Many empirical studies have investigated the relationship between bank loans growth and capital. Their authors explored also other significant factors that might mitigate or strengthen the relationship, or even change the directionality of causality within it entirely[23].

[23] Since the objective of the present dissertation is twofold, the literature review on the topic of determinants of QE policy impact on the relationship between bank lending and capital ratio must be conducted from

Bernanke and Lown (1991) in their empirical analysis of the so-called 'credit crunch' that occurred in the US economy in the early 1990s reached the conclusion that a shortage of bank capital was a primary factor reducing loan supply, although their evidence suggests that "in most [US] regions the capital shortage has had only a modest effect on the availability of loans" (Bernanke and Lown, 1991, p. 206-212). The main limitation of this study, as pointed out by Berrospide and Edge (2010), is the fact that the simple models used in the Bernanke and Lown's (1991) study do not take into account bank-specific variables (such as, e.g. bank size or profitability) and, in consequence, do not control for these bank-specific effects, and thus their results might be largely overestimated (Berrospide and Edge, 2010, p. 33-34). Hancock and Wilcox (1993) study was a follow-up and a more closer look at the 'capital-crunch' hypothesis put forward in Bernanke and Lown (1991). They found out that, indeed, the shortfall of banks' equity capital was an important restraint on bank lending during the period of credit (capital) crunch. A part of the reason for such behavior was that some banks were trying very intensively to satisfy (new) regulators' capital requirements (Hancock and Wilcox, 1993, p. 31). Summarizing this strand of research, Berrospide and Edge (2010) stated that "[a]lthough this debate did not yield a definitive conclusion, it did result in the development of empirical models that expressly sought to quantify the effect of bank capital on bank lending" (Berrospide and Edge, 2010, p. 7).

In a more recent study, Berrospide and Edge (2010) investigated the relationships between bank lending and capital ratio using more advanced econometric tools, such as panel methods and VAR model, on both institution-level and aggregate data. They reported only modest effects of capital (ratio) on bank lending, finding the relative more importance of other factors such as economic activity (that determines the aggregate demand for credit) and the increased perception of riskiness by banks (that strongly affects the supply of bank credit) (Berrospide and Edge, 2010, p. 52).

Carlson et al. (2013) applied a matched bank approach, obtaining the results that suggest that the relationship between bank loans and capital ratio is essentially non-linear. The non-linearity arises because, firstly, the capital impact on lending is stronger for banks that cut back lending and weaker for banks that extend their lending. Secondly,

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both the financial micro perspective as well as from the policy-making macroeconomic perspective. The latter remains a subject of Chapter 2 of the present dissertation.

their results clearly indicate that there apparently exists some threshold level of bank capital ratio above which the elasticity of bank lending with respect to capital ratios changes, and that most likely this threshold level is bank-specific. In particular, they found that the capital elasticity of bank lending is higher when capital ratios are relatively low, which suggests a non-linearity of the examined relationship (Carlson et al., 2013, p. 663). Furthermore, they also provided evidence that the capital effects on lending were significantly stronger during and shortly after the recent global financial crisis (Carlson et al., 2013, p. 678).

The explanation of these findings seems quite straightforward. During severe economic downturns like financial crises, banks face many defaults of their borrowers, and these losses on loans leading to higher loan loss provisions (LLPs) and large write-downs which are then absorbed by equity capital, in turn, leads to a capital depletion and, in the end, to a decline in capital ratios. In this situation (i.e., a situation in which banks face falling, and eventually very low, capital ratios), two factors come into play, namely the decreased bank's profitability and the pessimistic expectations held by the bank's owners, managers and investors. The two factors reinforce each other and seem to strongly affects the supply of bank loans, leading to its contraction. On the other hand, the demand-side factors, such as deteriorated borrowers' creditworthiness and the overall decline in the credit demand as general economic activity slows down, also play a significant role, especially during recessions[24].

In a study related to Carlson et al. (2013), Mora & Logan (2012), focusing on the UK banking sector in the pre-crisis (1990-2004) period found that there was a positive contemporaneous effect of capital on lending. Moreover, their study results were robust and, reportedly, avoided the endogeneity bias (i.e. possible effects of bank lending on bank equity capital) since not only a resident write-offs share has been controlled for, but also a specific (exogenous) capital shock was obtained by using write-offs on loans to non-residents. Thus, adopting a panel VAR approach, Mora & Logan (2012) estimated system Generalized Method of Moments (GMM) in which bank capital's impact on UK resident lending was instrumented by a non-resident share in loan write-offs. Although, on the whole, their estimates indicated a positive effect of contemporaneous capital on

[24] It is worth noticing that the above-presented explanation is fully consistent with the general framework, or a 'circular pyramid', that is introduced in Section 1.3 of the present dissertation and is shown in Figure 1.2.

bank lending, with a significantly stronger effect when the bank capital shock was instrumented (Mora & Logan, 2012, p. 1115), the specific effects were more diverse. That is, a one per cent growth in instrumented capital resulted in a more-than-one-percent increase in loans to non-financial companies but also caused a roughly three percent decline in loans to households (Mora & Logan, 2012, p. 1116).

In relation to quantitative-easing (QE) effects on the examined relationship, several authors strongly emphasize the liquidity effects and in particular banks' liquidity creation effects that can largely influence a bank's credit extension capacity. This body of research has intensively developed since an outburst of the global financial crisis (GFC). Nonetheless, it must be stressed that the empirical literature specifically focused on the direct effects of QE policy on the relationship between bank capital and lending is relatively scarce. The post-crisis studies that cover (the related to QE) liquidity effects on the capital-loans link include, *inter alia*, Berrospide (2013), Kim and Sohn (2017), and Casu et al. (2018). In essence, this research strand highlights the importance of bank-specific variables that appear to highly influence the complicated and nuanced bank capital-lending-liquidity nexus[25]. Table 1.1. reports the most relevant and significant (from the viewpoint of the present dissertation's objectives) empirical results of the post-crisis studies along with the evidence-based sign in the investigated relationship between bank capital ratios and lending, as revealed by reviewed studies in this body of research[26].

Table 1.1. Summary of the post-crisis empirical studies on the relationship between bank capital ratios and bank lending

Authors	**Main finding**	**Sample and research method**	**Sign in the relationship between bank capital (ratios) and lending**
Berrospide & Edge (2010)	• Find only modest effects of bank capital ratio changes on bank lending;	Quarterly panel data on large banks and bank holding	Find a positive sign but modest effects. "(…) our results in table 4 suggest that a 1-percentage-point

[25] Further studies that examine the nexus of bank capital, lending and liquidity creation in particular during and shortly after the recent GFC include Cornett, McNutt, Strahan, & Tehranian (2011); Garel & Petit-Romec (2017); and Ivashina & Scharfstein (2010). Although their research findings appear both interesting and important, nonetheless, since they do not directly analyze the relationship between bank capital (ratios) and loans growth, nor the possible third variables that might affect it, they are not further discussed in the present dissertation.

[26] It is worth noticing that, although all of the studies reported in Table 1.1. are post-crisis empirical investigations, the majority of them analyzed a sample span that is actually pre-crisis, or at maximum that ends only one or two years after the end of the GFC.

	• "(…) more important roles for factors such as economic activity and increased perception of risk by banks" (Berrospide & Edge, 2010, p. 7).	companies in the period 1992:Q1–2008:Q3. Panel Fixed effects (FE) estimator and VAR model.	increase in the capital ratio leads to a long-run increase in annualized BHC loan growth that is only between 0.7 and 1.2 percentage points" (Berrospide & Edge, 2010, p. 31).
Berger & Bouwman (2009)	• Find that the effect of bank capital on liquidity creation (including bank lending) depends on the size of a bank; • "(…) higher capital requirements […] may have associated with it reduced liquidity creation by small banks, but enhanced liquidity creation by large banks." (Berger & Bouwman, 2009, pp. 3833-34).	Annual panel data from 1993 to 2003. FE estimator and the Instrumental Variable (IV) estimator.	Find that the sign depends on a bank's size. "(…) the effect of capital on liquidity creation is significantly positive for large banks and significantly negative for small banks." (Berger & Bouwman, 2009, p. 3785).
Carlson et al. (2013)	• Find that effects of bank capital ratios on loans growth depends on the initial level of bank capitalization; • A positive association between capital ratios and loan growth is larger when the capital ratio is closer to the binding regulatory minimum requirement; analogously, it becomes smaller and less significant as the capital ratio increases (Carlson et al., 2013, p. 686). • "(…) banks whose actual capital ratios were relatively high had stronger loan growth from 2008 to 2010, during the recent financial crisis"	Annual panel data in the period 2001–2011. A matched bank approach using FE estimator.	Find that in general the relationship is positive but its strength depends on the initial level of a bank's capital ratio. "(…) the elasticity of bank lending with respect to capital ratios is higher when capital ratios are relatively low"; "(…) relationship between capital ratios and loan growth is stronger for banks where loans are contracting than where loans are expanding" (Carlson et al., 2013, p. 663).

	(Carlson et al., 2013, p. 683).		
Mora & Logan (2012)	• Find the overall positive effects of contemporaneous capital on bank lending, although the specific effects are dependent on whether it is lending to households or companies: • "A fall in capital brought about a significant drop in lending in particular, to Private Nonfinancial Corporations (PNFC). In contrast, household lending increased when capital fell" (Mora & Logan, 2012, p. 1103).	Half-yearly panel data that covers the period from 1990 to 2004. Panel VAR approach and the panel Generalized method of moments (GMM) estimator.	Find, in general, a positive sign in the relationship. However, the specific effect depends on the type of lending. "There was a positive effect of contemporaneous capital on lending: a 1% growth in capital was associated with a 0.28% growth in UK lending, which is significant at the 1% level" (Mora & Logan, 2012, p. 1115); "A 1% growth in capital (instrumented) increased PNFC loans by 1.06% but caused household loans to fall by about 3%. These results are robust to controlling for resident write-offs, GDP growth and bank-specific characteristics" (Mora & Logan, 2012, p. 1116).
Beatty & Liao (2011)	• Provide support for the capital crunch hypothesis, proving higher association between lending and risk-based capital ratios during recessions; • Find that in their lending large banks are more vulnerable to capital constraints in comparison to small banks; • "(…) banks with greater delays in expected loss recognition reduce their lending during recessions more than banks with smaller delays" (Beatty & Liao, 2011, p. 19).	Quarterly panel data in the period 1993:Q3–2009:Q2. Panel regressions and the Ordinary least squares (OLS) estimator.	Find that the sign in the relationship depends on the size of a bank. "(…) the effect of the capital crunch differs for small versus large firms. We show that the capital crunch […] occurs only for banks with total assets in excess of $500 million. For these banks the effect of capital on lending growth during recessions is significantly higher than during non-recessionary periods" (Beatty & Liao, 2011, p. 13). "(…) results suggest that capital regulation combined with greater delays in recognizing expected losses leads to the capital crunch on lending during recessions" (Beatty & Liao, 2011, p. 19).

Olszak, Chodnicka-Jaworska, Kowalska, & Świtała (2017)	• Find that banks that engage more in income smoothing practices are more sensitive to capital constraints in their lending; • "Consistent with capital crunch theory […] we find that lending depends on the level of capital ratio. However, recessionary capital crunch affects lending in the sample of poorly-capitalized banks" (Olszak et al., 2017, p. 6). • "(…) our results suggest that capital-buffers do not reduce the negative effects of discretionary income-smoothing, including e.g. increased risk-taking and decreased transparency (Olszak et al., 2017, p. 43).	Quarterly panel data in the period 2000:Q1–2012:Q4. Panel Fixed Effects (FE) estimator.	Find that the sign is in general positive, however, in the specific regressions it depends on the initial capital ratios of banks, i.e. the capital effects on lending differ for well- and poorly-capitalized banks. "(…) 1% decrease (increase) in capital ratio causes poorly-capitalized bank to decrease (increase) its lending by 1.724% […] In contrast, well-capitalized banks' loans growth is definitely less sensitive to capital ratio, because the whole effect of CAR is 0.036" (Olszak et al., 2017, p. 26).
Olszak et al. (2016)	• Find that the effects of bank capital ratios on lending is dependent on the specialization, size and initial capital ratio; • "The lending of poorly capitalized banks is more affected by the capital ratio than lending of well capitalized banks. Capital matters for the lending activity in contractions only in the case of savings and "low" capital banks" (Olszak et al., 2016, p. 56).	Annual panel data from 1996 to 2011. Two-step panel GMM robust estimator.	Find that in general the association between loans growth and the capital ratio is positive. The specific regressions reveal that strength of the relationship depends on bank size, initial capitalization, and bank type of specialization. "(…) cooperative and savings banks' lending is a little bit more capital constrained by the capital ratio than lending of commercial banks. We also find that 'high' capital banks can better shield their lending from contractions as well as are less capital constrained in their credit extension in expansions tha[n] 'low' capital banks" (Olszak et al., 2016, p. 56).

Kim & Sohn (2017)	• Find that relationship is contingent on the initial liquidity position which, in turn, depends on a level of initial liquidity ratio (i.e. whether a bank has sufficient liquid assets and thus if it has high liquidity ratios); • An association between bank capital and lending exhibits a complicated, i.e. a non-linear relationship (Kim & Sohn, 2017, p. 106).	Quarterly panel data from 1993:Q1 to 2010:Q4. Fixed Effects (FE) panel method estimator.	Find that the sign is dependent on bank size and initial relative liquidity ratios. "(…) bank capital exerts a significantly positive effect on lending only after large banks retain sufficient liquid assets" (Kim & Sohn, 2017, p. 95). "(…) the effect of an increase in bank capital on credit growth is significantly negative at low liquidity ratios, becoming significantly positive only after large banks retain sufficient liquid assets" (Kim & Sohn, 2017, p. 106).
Casu et al. (2018)	• Find that a relationship between bank liquidity creation and capital ratios may actually be non-positive; • "(…) we find a bi-causal negative relationship, which suggests that banks may reduce liquidity creation as capital increases; and when liquidity creation increases, banks reduce capital ratios" (Casu et al., 2018, p. 1).	Annual panel data over the period 1999–2013. Simultaneous equations model with the panel GMM estimator.	Find a negative relationship between capital ratios and the liquidity creation; however, the sign depends specifically on the type of bank's specialization. "Our results show a negative relationship between capital ratios and our liquidity creation proxy, suggesting that banks may reduce liquidity creation as bank capital increases, thus providing evidence in support of the 'financial fragility-crowding out hypothesis'"; "(…) we find that the [above] result does not hold for savings banks, which appear to increase their liquidity creation when their capital increases. For these types of banks, the 'risk absorption' capacity of equity capital is an important driver to explain liquidity creation" (Casu et al., 2018, pp. 3-4).
Roulet (2018)	• Finds that capital ratios exert a significant and negative impact on large banks' retail loans;	Annual panel data over the period 2008–2015. OLS panel estimator with bank cross-	Finds in the post-crisis sample period a negative relationship between capital ratios and bank retail lending growth. "The main results show that capital ratios have significant and negative impacts on large

	• Regarding liquidity ratios, the general effect on lending is dependent on the type of lending, i.e. whether it is commercial or retail bank lending (Roulet, 2018, p. 34).	section fixed effects.	European bank-retail-and-other-lending-growth" (Roulet, 2018, p. 28). Finds also that liquidity effects on lending differ on loans type: "(…) the ratio of nonrequired amount of stable funding to total assets has a significant and positive impact on European bank-commercial-lending-growth. […] Nevertheless, the ratio (…) has a significant and negative impact on European bank-retail-and-other-lending-growth" (Roulet, 2018, p. 34).
Naceur, Marton, & Roulet (2018)	• Find that capital ratios exert a significant and negative impact on large European banks' retail loans; • Regarding liquidity ratios, they find that their effects differ for US and European banks: "(…) the ratio of the available amount of stable funding to total assets is not significant in determining European bank-lending-growth regardless of size. However, the ratio […] has a significant and negative impact on retail-lending-growth for large U.S banks" (Naceur et al., 2018, p. 17).	Annual panel data over the period 2008–2015. OLS panel estimator with bank cross-section fixed effects.	Find that in the US the relationship is positive especially for small US banks, as it differs on bank size and type of lending. In Europe, however, they find the sign to be negative especially for the large banks' retail-lending-growth (Naceur et al., 2018, p. 2). Find also that liquidity effects on lending differ on the loans type: "For large European banks, the ratio of the non-required amount of stable funding to total assets has a positive impact on commercial-lending-growth, but a negative effect on retail-lending-growth" (Naceur et al., 2018, p. 17).

Source: own elaboration based on the reviewed empirical studies.

From the perspective of bank loan loss provisions (LLPs), Olszak, Chodnicka-Jaworska, Kowalska, & Świtała (2017) found that banks that practice income smoothing to a large extent (such as adjusting the level of LLPs to stabilize earnings) are more prone to be capital-constrained in their lending during recessions. In general, they also supported the capital crunch theory finding that bank lending indeed depends on the level of capital ratios. In particular, they came to the conclusion that even well-capitalized banks that engage in profit-stabilization practices are not resilient to capital shocks during recessions (Olszak et al., 2017, p. 43).

Olszak et al. (2017) followed the approach of Beatty & Liao (2011) who investigated the role of loan-loss accounting in the relationship between bank capital and lending, and supported the capital crunch hypothesis, proving higher association between lending and risk-based capital ratios during recessions. Specifically, Beatty & Liao (2011) found that banks with greater delays in the (expected) credit loss recognition reduce their lending more in recessions compared to banks with smaller delays. Furthermore, the former group of banks is also more subject to capital crunches in recessions. Thirdly, according to their results, lending of large banks is more vulnerable to capital constraints in comparison to lending by small banks (Beatty & Liao, 2011, p. 19).

From the financial and regulatory microeconomic perspectives, a crucially important consideration for bank capital, loans and liquidity situation is a prescriptive regulatory framework. Early investigations of the impact of capital regulations on bank lending and risk-taking were rather critical about the effectiveness of these (new) regulatory instruments. For instance, Calem & Rob (1999) argued that although "minimum capital standard – whether or flat or risk-based – can, in principle, curtail the risk-shifting benefits of deposit insurance and the associated moral hazard," their analysis showed that "it is difficult to regulate the risk-taking behavior of well-capitalized banks by means of a risk-based standard, which is a rather blunt instrument" (Calem & Rob, 1999, pp. 320-321).

The effect of the new Basel III capital accord on bank lending activities in US and in Europe is covered in two recent studies, namely in Naceur et al. (2018) and in a related paper by Roulet (2018), respectively[27]. They are related to each other with regard to many aspects. First, in contradiction to a majority of reviewed studies (e.g., Carlson et al., 2013;

[27] The new Basel III capital and liquidity adequacy framework has been proposed as a part of a broader macro-prudential and regulatory response to address the crucial shortcomings of banks' capital and risk management practices during and shortly after the GFC. The Basel III minimum capital requirements regulations started being phasing-in in 2014. In Europe, the Basel III accord comes into force through the UE regulations and directives, namely: *Capital Requirements Regulation* (CRR) and *Capital Requirements Directive IV* (CRD IV) (Olszak & Olszak, 2014, p. 10). For a summary of the main innovations of the new capital requirements see BIS, 2017; Casu et al., 2018, pp. 1-2; and for further technical and regulatory details, see Olszak & Olszak, 2014.

Mora & Logan, 2012; Olszak et al., 2016 – see Table 1.1 for details), both Naceur et al. (2018) and Roulet (2018) found a negative relationship between capital ratios and bank lending for large European banks. They both reported that "capital ratios have significant and negative impacts on large European bank-retail-and-other-lending-growth in a context of deleveraging and 'credit crunch' in Europe over the post-2008 financial crisis period" (cf. Naceur et al., 2018, p. 1; Roulet, 2018, p. 26). Moreover, their main finding, that is, the empirical evidence of banks, facing more stringent capital requirements, engaging in substituting risky loans with less risky assets – is consistent with the similar result obtained by Mora & Logan, 2012. The difference being the phase of economic cycle in which banks exhibit this behavior, since Naceur et al. (2018) and Roulet (2018) found that "more stringent capital adequacy rules encourage substitution out of retail-and-other loan assets into risk-free, more liquid government bond securities" in the post-crisis period (Roulet, 2018, p. 28); whereas Mora & Logan (2012) reported that "[…] result indicates that – in this pre-crisis period – banks substituted away from risky PNFC loans into potentially less risky loans when capital was short" (Mora & Logan, 2012, p. 1104).

In summary, all of this seems to suggest that, notwithstanding the economic cycle, whether in an economic downturn or an upturn, banks exhibit quite similar behavior. Following a negative shock to bank capital banks may not only curtail their lending growth but actually replace existing risky loans with more safe assets. In particular, more stringent capital adequacy rules tend to encourage banks to substitute out of business loans into safer household loans – in the case of a pre-crisis period (Mora & Logan, 2012), and substitute away from widely regarded risky retail loans into more safe, risk-free government bonds – in the case of a post-crisis period (Naceur et al., 2018; Roulet, 2018).

In conclusion, the main findings of the reviewed empirical studies (summarized in Table 1.1) are as follows. First, bank-specific characteristics, among which most often reported are bank size, liquidity ratios and the initial level of capital ratios, all matter for both sign and strength of the relationship between capital ratios and bank lending. Second, in the broad majority of the reviewed post-crisis empirical studies the sign in the association between bank lending and capital ratios is in general positive (Berrospide & Edge, 2010; Carlson et al., 2013; Kim & Sohn, 2017; Mora & Logan, 2012; Małgorzata Olszak et al., 2017, 2016). Thirdly, though some studies, notably Casu et al. (2018); Naceur et al. (2018); and Roulet (2018) have found a general negative link in the examined relationship, their results must be cautiously read for several reasons. One is that, for example, Casu et al. (2018) in their regressions used various proxies of liquidity creation which is similar but not exaclty equal to bank lending. In turn, Naceur et al. (2018) and Roulet (2018) have emphasized and revealed that different results that can be obtained depending on whether the total bank lending (growth) or the dynamics of its disaggregated components such as the growth of retail and other lending, the commercial lending growth and other factors are considered.

1.5 Summary and research questions

A review of both the theoretical literature in Section 1.3 and the evidence produced by empirical studies in Section 1.4 allows me to assert some specific implications, propositions and verifiable research questions that can be tested in the further parts of the present dissertation.

First of all, both the reviewed theoretical literature, such as Bernanke et al. (1996); Mishkin (1991); Sharpe (1995); Stiglitz & Weiss (1981); Van den Heuvel (2002), and empirical evidence present in, for example Beatty & Liao (2011); Brei et al. (2013); Carlson et al. (2013); Casu et al. (2018); Kim & Sohn (2017); Olszak et al. (2016) tend to support the *non-linearity view* on the relationship between bank capital ratios and a bank lending. From the theoretical perspective, the cause of such non-linearity can be non-measurable asymmetric-information phenomena, such as moral hazard and negative selection; whereas from the empirical perspective, it can be a result of bank-specific variables such as, bank's size, specialization, and initial capitalization, etc. In any case, in essence due to this complicated and complex nature of the examined relationship and many potentially significant 'third variables' that can affect it, effects of bank capital ratios on the loans growth are likely to be non-linear and dependent on some particular conditions and specific variables. This observation allows me to formulate five following research questions[28].

Firstly, most of the reviewed literature and empirical studies report that in addition to the non-linear nature, the relationship between capital ratios and bank lending is also

[28] These research questions are summarized in Table 1.2 along with the relevant studies and logical argumentation that support them.

in general positive. It may arise because well-capitalized banks can extend more loans as they are able to more effectively absorb loan losses (i.e., materialized credit risk), and thus can less costly mitigate the negative effects of credit risk related to lending (Bernanke & Lown, 1991; Berrospide & Edge, 2010; Carlson et al., 2013; Hancock & Wilcox, 1994; Kim & Sohn, 2017; Mora & Logan, 2012; Małgorzata Olszak et al., 2017, 2016; Peek & Rosengren, 1995). Moreover, this view is fully consistent with the 'risk absorption' hypothesis (Berger & Bouwman, 2009; Kim & Sohn, 2017). Accordingly, I derive the following two research questions in the context of the study period and sample used in the present study:

> Q1: *Was the relationship between bank capital ratios and bank loans growth for European banks in the 2011-2018 period non-linear?*

> Q2: *Was the sign in the relationship between bank capital ratios and bank loans growth for European banks in the 2011-2018 period in general positive?*

Secondly, there is a wide range of potentially relevant variables that according to reviewed empirical studies tend to moderate and significantly affect the examined relationship. Specifically, three sets of bank-specific factors stand out. The first set comprises of bank size variables and banks' general characteristics, such as bank type and specialization. These variables have been demonstrated significant in a number of studies, particularly in Beatty & Liao (2011); Berger & Bouwman (2009); Casu et al. (2018); Kim & Sohn (2017); Kishan & Opiela (2000); Naceur et al. (2018); Olszak et al. 2016). In line with these research results, I derive the following, third empirical questions:

> Q3: *Did the relationship between bank capital ratios and bank lending growth depend on a bank's size and specialization in the 2011-2018 period for European banks?*

The second set of significant bank-specific factors contains the initial level of a capital ratio (i.e., bank-specific initial capitalization level). A number of studies, including Brei et al. (2013); Carlson et al. (2013); Hancock, Laing, & Wilcox (1995); Olszak et al. (2017); Peek & Rosengren (1995) point to this factor as relevant and especially crucial at the moment when a capital shock hits a particular bank. Accordingly, I derive the following, fourth research question:

Q4: *Did the relationship between bank capital ratios and bank lending growth depend on the bank's initial level of capitalization (that is, the initial capital-to-asset ratio) in the 2011-2018 period for European banks?*

The third set of significant bank-specific factors consists of liquidity indicators and ratios, such as the ratio of bank's liquidity position to total assets, and more generally indicators such as loan-to-deposit (LTD) or liquid assets to total assets ratios[29]. This aspect has been emphasized in a number of reviewed studies, particularly in Berrospide & Edge (2010); Casu et al. (2018); Kim & Sohn (2017); Mora & Logan (2012); Naceur et al. (2018); Roulet (2018). In accordance with these studies, I derive the following, fifth testable research question:

Q5: *Did the relationship between bank capital ratios and bank lending depend on the bank's relative liquidity position expressed in its liquidity ratios in the 2011-2018 period for European banks?*

Table 1.2. reports a summary of the formulated testable research questions in addition to a review of the hypothetically significant bank-specific effects that, according to both theoretical and empirical evidence, tend to moderate the relationship between bank capital ratios and bank lending.

Table 1.2. Summary of significant bank-specific effects that affect the relationship between bank capital ratios and bank lending

Significant effect	**Studies**	**Logical argumentation**
Research question 1: *non-linearity*	(Brei et al., 2013; Calem & Rob, 1999; Carlson et al., 2013; Casu et al., 2018; Hancock & Wilcox, 1993; Kashyap & Stein, 2000; Kim & Sohn, 2017; Kishan & Opiela, 2000; Małgorzata Olszak et	A non-linearity in the relationship between bank capital ratios and lending may arise due to many factors and circumstances. Any significant factor – or a 'third variable,' or an 'omitted variable' – can exert an impact on the sign and strength of this relationship. A factor can either moderate some of the causal relationships in the environment of the examined relationship (see Figure

29 Where in the case of LTD ratio, a large value indicates that a bank can be considered illiquid and a low value shows the opposite.

	al., 2017, 2016; Sharpe, 1995)	1.2 for details), or it can directly affect the studied link. That is, it can affect either the effects of capital ratios on bank lending, or the effects of lending on capital ratios, and thus can produce the net effect running in one or the other direction, depending on the specific circumstances.
Research question 2: *a positive sign in the bank capital-lending relationship*	(Bernanke & Lown, 1991; Berrospide & Edge, 2010; Carlson et al., 2013; Hancock & Wilcox, 1994; Kim & Sohn, 2017; Mora & Logan, 2012; Małgorzata Olszak et al., 2017, 2016; Peek & Rosengren, 1995)	The expected effect of capital ratios on bank lending is positive, since, according to the so called 'risk absorption' theory, it is likely that well-capitalized banks extend more loans primarily because they can more effectively absorb loan losses (i.e., materialized credit risk), and thus can less costly mitigate the negative effects of credit risk related to lending (see also Berger & Bouwman, 2009; Kim & Sohn, 2017).
Research question 3: *bank size and specialization*	(Beatty & Liao, 2011; Berger & Bouwman, 2009; Casu et al., 2018; Kim & Sohn, 2017; Kishan & Opiela, 2000; Naceur et al., 2018; Małgorzata Olszak et al., 2016)	Small cooperative and savings banks may face more constraints on lending and may face higher costs to refinance its lending in the interbank money market or raise new capital in the stock market. As a result, their lending may be to a large degree reliant on retail deposits inflow and on their own funds (that is, their Tier 1 capital positions).
Research question 4: *initial level of capitalization (e.g., the initial capital-to-asset ratio)*	(Brei et al., 2013; Carlson et al., 2013; Hancock et al., 1995; Małgorzata Olszak et al., 2017; Peek & Rosengren, 1995)	A positive association between capital ratios and loan growth is larger when the capital ratio is closer to the binding regulatory minimum requirement; analogously, it becomes smaller and less significant as the capital ratio increases (Carlson et al., 2013, p. 686).
Research question 5: *relative liquidity position (e.g., the loan-to-deposit ratio)*	(Berrospide & Edge, 2010; Casu et al., 2018; Kim & Sohn, 2017; Mora & Logan, 2012; Naceur et al., 2018; Roulet, 2018)	The relationship between bank capital ratios and lending may be contingent on the initial liquidity position (which, in turn, depends on a level of initial liquidity ratio, i.e. whether a bank has sufficient liquid assets and thus if it has high liquidity ratios) because even seemingly illiquid banks may encounter problems with refinance its lending both in the interbank money market and in the stock market (Kim & Sohn, 2017; Mora & Logan, 2012; Naceur et al., 2018).

Source: own elaboration.

Chapter 2. Monetary policy as a determinant of bank lending

2.1 Theoretical review of monetary policy transmission channels

Monetary policy transmission mechanism is a vital and very practical concept for central banks. However, theoretical review thereof, due to its detailed and most often country-specific nature is complicated endeavor, and as a result, it requires some degree of generalization and the acceptance of some stylized facts.

The problem of how an initial impulse originated by a central bank is transmitted to the broader economy is an issue of great importance. Whether it is an interest rate change, or a recalibration of an asset purchase program, both decision makers at a central bank and market participants are vitally interested in knowing (and predicting) what short-term and long-term consequences of some specific and stipulated actions should be.

According to ECB (2011), a monetary transmission mechanism is “the process through which monetary policy decisions affect the economy in general, and the price level in particular” (ECB, 2011, p. 58). Therefore, such mechanism answers the question of what is exactly the impact of some stipulated (administrative) policy or decision on broad economy and on price developments in particular. This is essentially consistent with the primary objective of the most of central banks, which is the price stability maintenance or, in other words, pursuing the monetary policy of which an overriding principle is to keep the inflation rate low and stable[30].

Although the monetary transmission is a highly practical and relevant tool of monetary policy, it is also a concept that is complex, involves many stages, and is based on many postulated cause-and-effect relationships which in practice can be found to hold only partially or only under some specific conditions (assumptions). Moreover, the monetary transmission process of both standard and non-standard measures necessarily involves long and uncertain lags as the maximum effect is often observed between one and two years after an initial monetary decision (ECB, 2011, p. 62). On the other hand, as Berk (1998) stressed, high uncertainty around the monetary transmission has not diminished recently (even with the birth of the unconventional monetary policy – one can

[30] The principle of keeping the inflation rate low over some specified horizon (usually over the medium term) is the core of the so-called direct inflation targeting strategy of monetary policy.

argue that the uncertainty of the monetary transmission has actually increased). This fact was already acknowledged many decades ago. As Berk (1998) points out:

> "[s]ince the pioneering work of Milton Friedman (1961), the existence of a considerable and varying time lag between the actions by the central bank in adjusting its policy instruments and the effects on the target variable is generally acknowledged. Because of these lags, the monetary policy maker must take a forward-looking approach in his decision making. Central elements in the latter process include a forecast of the target variable over some horizon, and views on the transmission mechanism between the adjustment in the policy instrument and the policy goal (Freedman 1996)" (Berk, 1998, p. 145).

Nowadays, as the economy of many countries has evolved and the financial markets have significantly changed the way they operate, economists have to deal with various new problems and challenges (for a discussion on this see: Boivin, Kiley, & Mishkin (2010). In particular, the question of what is the transmission mechanism of the non-standard measures of monetary policy, notably the quantitative easing (QE) or the large-scale asset purchase (LSAP) policies, and how many stages and lags it involves, remains both valid and critically important questions. On the theoretical level, I will try to answer them in the next subsections.

2.2 General monetary transmission mechanism

The approach adopted in the following paragraphs is, first, to describe the monetary policy measures based on Borio & Zabai (2016) taxonomy. In the second place, a general case of the monetary transmission mechanism based on Beyer et al. (2017) and ECB (2011) is presented. Thirdly, in next sections, the general transmission mechanism is reviewed along with its propagation channels and the effects related to a standard (conventional) monetary policy impulse, i.e., an interest-rate impulse. Finally, the effects related to a non-standard (unconventional) monetary policy impulse in the form of an adjustment in asset purchases are presented.

Before moving on to the proper analysis of the specific propagation mechanisms of monetary policy impulses, it is worthwhile to discuss some taxonomic (classification) issues at this stage. First, as some authors, notably Bernanke (2009), distinguish the unconventional monetary policy measures by putting an emphasis on the distinction between the quantitative easing and credit easing policies. The distinction is based on whether the central focus is put on either the asset side of the central bank's balance sheet or on the liability side of it.

Bernanke (2009) argues that what the Fed initially committed to do, and what eventually it did, should be called credit easing because its approach "focuses on the mix of loans and securities that it holds and on how this composition of assets affects credit conditions for households and businesses" (ibid.). The common and key feature of both quantitative easing (QE) and credit easing policies is that they involve an expansion of the central bank's balance sheet[31] (Bernanke, 2009). In this broader sense, the QE policy, which is more widely used term in the academic literature, is preferable to employ over the credit easing. This is consistent with the precise taxonomy of unconventional monetary policy measures offered in Borio & Disyatat (2009) and Borio & Zabai (2016). As the latter authors stressed, the argument is that "[t]he term 'quantitative easing' nowadays has become almost synonymous with domestic balance sheet policies in general (…)" while "[t]he term 'credit easing' is typically restricted to those domestic balance sheet policies that target the asset side of the balance sheet and ignore what happens on the liability side" (Borio & Zabai, 2016, p. 6).

Based on the taxonomy of monetary policy measures both of the conventional and unconventional tools developed in Borio & Zabai (2016), in the present thesis the useful distinction is made not between credit and quantitative easing as such. It is rather made between the balance sheet policy – defined as "[a]djusting the size/composition of the central bank balance sheet and influencing expectations about its future path to influence financial conditions beyond the policy rate" – and the interest rate policy which these authors defined as "setting the policy rate and influencing expectations about its future path" (Borio & Zabai, 2016, p. 3). Table 2.1 provides a taxonomy of monetary policy measures, including both the standard and unconventional tools. The taxonomy crucially relies on markets that the central bank targets with its monetary operations or its forward guidance communications (Ibid.). Along with the review of monetary policy measures,

[31] In this sense the QE policy, i.e., monetary policy that necessarily and purposefully involves an expansion of the central bank's balance sheet, is also used in the present thesis.

Table 2.1 provides a description of each of a tool or policy measures that can be adopted by modern central banks.

Table 2.1. General taxonomy of standard and unconventional monetary policy measures

Policy measure	Description
A. Interest rate policy	Central bank sets its policy rate and influences the public expectations about the future course of its monetary policy
A1. Forward guidance on interest rates	Central bank communicates information on the future path of its policy rate to financial markets participants and to the general public
A2. Negative interest rates	Central bank sets its policy rate below zero
B. Balance sheet policies	Central bank adjusts the size and/or composition of its balance sheet and influences the public expectations about the future course of its monetary policy to influence financial and credit markets' conditions beyond the policy rate
B1. Exchange rate policy	Central bank intervenes in the foreign exchange (FX) market
B2. Quasi-debt management policy	Central bank conducts operations that target the market for public sector debt, i.e., it purchases or sells debt issued by the government and its agencies
B3. Credit policy	Central bank performs operations that target private debt and securities markets, including financial instruments issued by banks
B4. Bank reserves policy	Central bank undertakes operations that target the market for central bank reserves (held by banks), that is, bank reserves In particular, bank reserves policy can aim directly at providing banks with large amounts of (excess) reserves
B5. Forward guidance on the balance sheet	Central bank communicates the future path of its balance sheet in terms of its size and/or composition

Source: own elaboration based on Borio & Zabai (2016, p. 3).

The standard mostly used monetary policy measure is the interest rate policy. It consists in changing the level of official short-term interest rates (in Table 2.1 they are referred to as the 'policy rate'). These rates are the money market interest rates that are in practice to a very large extent controlled by a central bank via its routinely conducted monetary operations, i.e. through a process of suppling or withdrawing central bank reserves from the banking system.

Relatedly, the central bank conventional policy can be strengthened by a proper and timely communication and signaling. If this communication concerns the future path of the official (policy) interest rate, then the central bank engages in the forward guidance on interest rates (A1 measure in Table 2.1). This measure which is widely regarded as unconventional monetary policy tool itself focuses on influencing market participants' views and beliefs (i.e., the signaling mechanism), and thus it allows central bankers to steer the market expectations to make them consistent with adopted monetary policy stance (Borio & Zabai, 2016, p. 10).

In the post-crisis period some central banks, notably the ECB and BOJ, adopted the negative interest rate policy. As Table 2.1 indicates these central banks decided to lower their deposit (or deposit facility) rate below zero. As far as negative interest rate policy (NIRP) is concerned, the central bank's nominal interest rates are effectively limited by the lower bound, which means that because of a threat of the public converting bank money to cash, and because of cash holdings having significant costs attached to it, central bank nominal interest rates cannot be reduced very deeply into negative territory[32]. In fact, when these two central banks decided to apply the negative deposit interest rates, the ECB in 2014 and the BOJ in 2016, they set their respective deposit rates only slightly below zero, i.e. at the level of minus 0.10 per cent[33] (see Table 2.1).

Balance sheet policies, specifically the balance-sheet mechanics of quantitative easing (QE) have been explained in a number of journal articles and central bank papers (see *inter alia*, Bedford, Berry, & Nikolov, 2009; Behrendt, 2017; Lavoie & Fiebiger, 2018; McLeay, Radia, & Thomas, 2014; Sheard, 2013). The balance-sheet mechanics follows the logic of a simple yet both ubiquitous and fundamental principle of double-entry bookkeeping. However, in order to enhance the understanding of all possible channels through which the balance sheet policies may impact the financial sphere (e.g., the banking sector) as well as and the real side of the economy (such as private sector spending), it is worth studying in detail all possible channels and effects. A description of how non-standard measures (like the QE) may affect non-bank financial firms, such as

[32] For a recent and comprehensive analysis of implementation issues of the monetary policy in a negative interest environment, see (Boutros & Witmer, 2020).
[33] Other countries whose central banks decided to introduce the negative interest rate policy (NIRP) include Switzerland, Sweden and Denmark. As the BOJ (2016) indicated in its official statement, "[t]he Bank will apply a negative interest rate of minus 0.1 percent to current accounts that financial institutions hold at the Bank.1 It will cut the interest rate further into negative territory if judged as necessary" (BOJ, 2016, p. 1).

pension funds, hedge funds, life insurance companies and unit trusts, is beyond the scope of the present thesis[34].

A well-suited theoretical tool that enables investigation of consequences of conventional and unconventional measures of the monetary policy is a proposed general monetary transmission mechanism. As illustrated in Figure 2.1, it is 'general' because it allows to analyze both impulses connected to the conventional monetary policy and impulses related to unconventional measures, such as the quantitative easing programs. Therefore, instead of focusing on the narrow theoretical analysis of balance sheets similar to the one presented by Sheard (2013) or by McLeay et al. (2014), the monetary transmission is next presented and analyzed in detail.

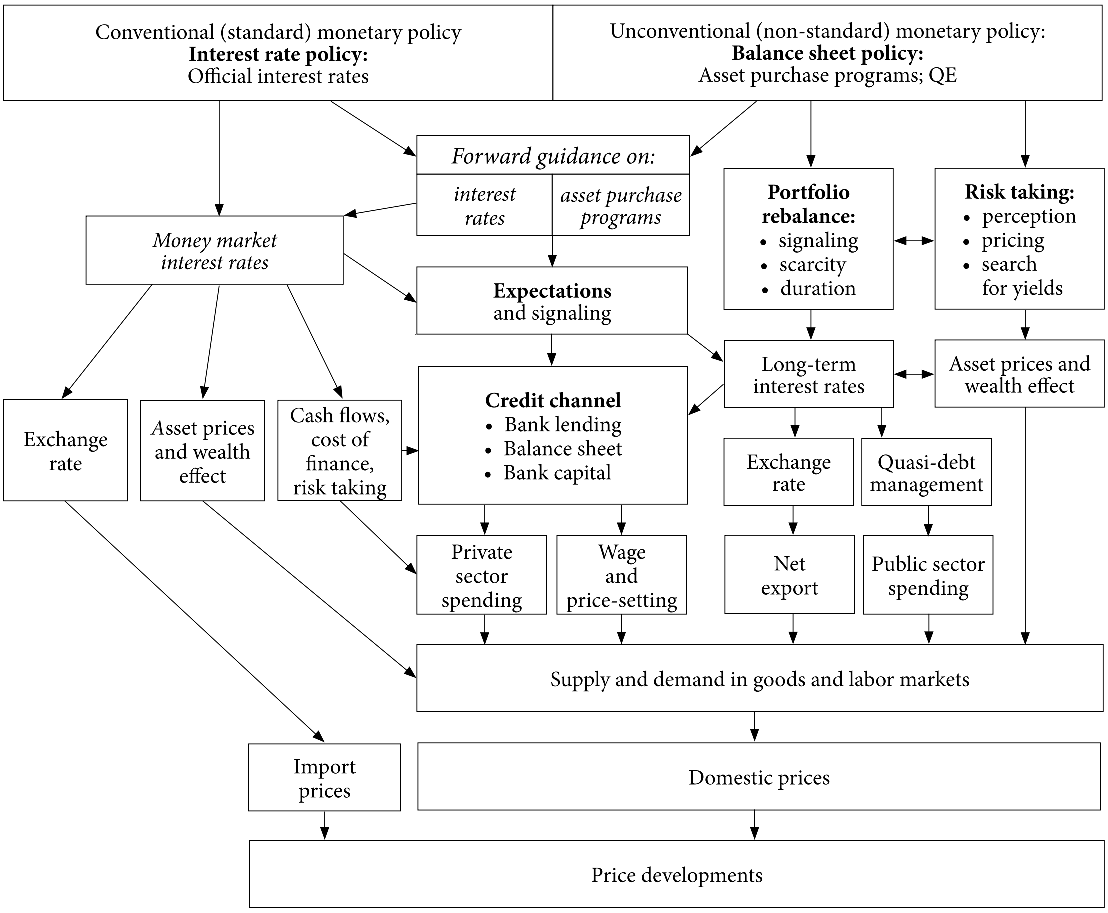
Figure 2.1. depicts an original model of the general monetary transmission mechanism which is based on the works of Beyer et al. (2017); Borio & Disyatat (2009); Borio & Zabai (2016); Borio & Zhu (2012); ECB (2011) and IMF (2013). It is a generalized monetary macroeconomic framework of monetary policy. It enables a broad and coherent explanation and investigation of standard interest-rate impulses and adjustments to the non-standard asset purchase programs. In distinguishing the unconventional monetary transmission mechanism from the conventional one it is important to emphasize the independence of standard interest rate policy from unconventional balance sheet policy, which is asserted and obtained consistently with the 'decoupling principle'.

According to the decoupling principle, "[t]he same amount of bank reserves can coexist with very different levels of interest rates; [and] conversely, the same interest rate can coexist with different amounts of reserves (Borio & Disyatat, 2009, p. 3). What is crucial in this regard is the way in which (excess) bank reserves are remunerated relative to the policy rate. Central banks that adopted unconventional monetary policy in the form of large-scale asset purchase can simply decide to remunerate excess reserves holdings at the key (or reference) policy interest rate (Ibid., p. 4). In such monetary policy implementation framework, the central bank can massively provide (flood) the banking sector with additional excess reserves, effectively incorporating the so-called 'floor system', in which a central bank can extend its balance sheet freely and massively without

[34] For the UK, the non-bank financial sector is succinctly summarized in Burrows & Low (2015). The design, operation and effects of the UK's quantitative easing are well described in Joyce, Tong, & Woods (2011).

any consequences for the money market interest rates, that is, independently of what the official interest rate level is considered to be appropriate[35] (Borio, 1997; Borio & Disyatat, 2009; Borio & Zabai, 2016).

Figure 2.1. General transmission mechanism of monetary policy



Source: own elaboration based on Beyer et al., 2017; Borio & Disyatat, 2009; Borio & Zabai, 2016; Borio & Zhu, 2012; ECB, 2011; IMF, 2013.

It is worth beginning the analysis with a monetary policy impulse in the form of a change in the rate of interest, that is a standard measure of the interest rate policy. First, a central bank is the sole issuer of cash (i.e., banknotes and coins) and bank reserves, hence it can set the price of these financial assets. As a result, the central bank can steer the money market interest rates very close to the officially stipulated central bank policy

[35] An alternative solution to adopting the floor system - that enables the central bank to conduct the large-scale (structural) asset purchase transactions independently of the interest rate policy - is to sterilize each one of the outright (sell or buy) transactions. Under this regime, the interest rate on excess reserves can be set below the key (policy) interest rate (Borio & Disyatat, 2009, p. 5).

interest rates. This process is known as an implementation of monetary policy and involves a conduct of cyclical (usually weekly – but can be also daily) main and fine-tuning open market operations (OMOs). These market operations aim to add liquidity or withdraw excess liquidity from the banking system, leaving there only the portion of reserves that is consistent with the central bank's operational target of the key (official) interest rate. This operational procedure is also known as liquidity management operations (see Borio & Disyatat, 2009, p. 2; or ECB, 2011, p. 59).

Secondly, in the post-crisis period when most central banks face the effective lower bound (ELB) as the ultimate constraint on the nominal interest rate policy, central banks began to use communication in the form of forward guidance. This allows them to reinforce the market operations effects by committing to keep the interest rate at some (low) level for the extended period of time[36]. Thus, the steering (or nearly full control over) short-term interest rates has been effectively extended to also exert some effect on the medium-term interest rates or even on long-term interest rates, through the expectations (signaling) channel. In Figure 2.1, this effect can be seen as an arrow coming from the forward guidance on interest rate to the market participants' expectations and leading into the long-term interest rates (e.g., yields on bonds).

A monetary-policy induced change in the money markets interest rates has three channels of further propagation in the economy. First, the short-term market rates (most often in the form of three-month interbank offered rates – IBOR) are the main component for bank lending rates. In basic terms, a bank loan rate can be imagined as an IBOR rate enlarged by a bank's profit margin. This amount constitutes the main part of (variable) interest rates on existing and new bank loans. As a result, a decrease in the official (central bank), which transmits to lower money market rates, reduces the cost of finance of new loans for households and firms and, in turn, increases their cash flows at the expense of the banking interest income in the case of existing stock of loans. A reduction of money market rates, furthermore, allows banks to re-finance (fund) their lending less costly by obtaining relatively cheap liquidity through the wholesale interbank (secured or unsecured) deposits markets.

[36] The effective lower bound by some authors is also referred to as the zero lower bound (ZLB), which is, however, not a very precise term since the minimum value for a nominal interest rate may be effectively (i.e., taking into account carry and store cost of the cash) below the zero.

The second traditional channel of a monetary-policy induced change in the money markets interest rates is its effect on a whole spectrum of financial assets' prices. A diminished discount rate (a lower discounting factor) directly leads to higher valuation of assets. Analogously, an increased money market rates tend to lower the price of debt instrument (e.g., bonds) and other securities (such as stocks, or interest-based derivatives). In a nutshell, the rising prices of financial assets result in higher financial wealth, which in turn, tends to have a positive impact on consumption and investment in the private sector, through the so-called wealth effect (cf. Beyer et al., 2017; ECB, 2011).

The third effect of a change in the money markets rates is a tendency that it affects the exchange rate. And while this channel depends on many other factors such as the size and the degree to which an economy is open to foreign trade, it remains import and valid even for a large and relatively open economy of the eurozone. The mechanism seems straightforward, as any increases in the interest rate result in the pressure for an exchange rate to appreciate and, analogously, a decrease in the rate of interest, through foreign capital outflow tends to depreciate the exchange rate. This exchange rate channel works in two ways. First, an exchange rate depreciation leads to a higher net export and thus it increases the domestic economic growth (as measured by GDP) which can translate into a stronger domestic aggregate demand growth. However, such a domestic currency depreciation tends also to increase the price of import, and as a result, is likely to increase the inflation pressure in the economy. All the theoretical connections and described channels can be seen in Figure 2.1.

Now, I will move to the analysis of a non-standard monetary policy impulse in the form of a change in the amount of assets purchases, or in other words, in the adjustment to the size of central bank's balance sheet (hence a balance sheet policy). At the first stage, the monetary-policy induced (QE) impulse goes through the microstructure of the bond (or other purchased securities) market[37]. A single large player (buyer) that enters a particular securities market is likely to cause some significant changes to the market, including a sudden change in the participants' pricing behavior. Most evidence point to three major (direct) channels through which large-scale government bond purchases

[37] The market microstructural mechanics related to an initial asset-purchase impulse is covered in a number of recent mostly empirical studies of the effects of the QE policy implemented by central banks. An in-depth analysis of these phenomena is beyond the scope of the present thesis. However, some of these aspects are a subject of Section 2.3 of the present dissertation.

transmit to long-term interest rates (Borio & Disyatat, 2009, pp. 13-14; IMF, 2013, pp. 9-10).

Firstly, direct (outright) assets purchase is at first instance causing the so-called scarcity effect. It is related to the fact that a very large buyer, such as the central bank, through its purchases effectively reduces the supply of a specific type of bonds available for trading. Based on the preferred-habitat theory of the yield curve (or simply segmentation of the bond market), some investors have a particular preference towards, for example, specific maturity of bonds (i.e., the 'preferred habitat'). As a result, they are not willing to part with such securities, and if forced, only for a very high price (which implies a very low yield). In the situation of investors having strong (likely regulatory induced) preferences on some specific bonds, and while the total supply of these bond is – at least in the short-run – limited, the scarcity effects occur, and thus because of the lack of close substitutes, the price of these securities tend to rise and the associated long-term interest rates (i.e., bond yields) begin to fall.

Secondly, one can observe the duration effect caused by large-scale asset purchases. Whenever a central bank purchases long-term government bonds it effectively removes the interest rate risk (as measured by the bond duration[38]) from investors' portfolio. The central bank thus removes some part of the risk premium – associated with a bond maturity, coupon structure, and coupon rate – from the market. This central bank's operation has two distinct consequences. Firstly, as a result of such purchases, investors' portfolio become safer (i.e., less sensitive to changes in the interest rate). Secondly, the yields (such as bond YTM) on the government bond decrease simply because they no longer must compensate for the interest rate risk. Similar to the scarcity effect, by contributing to falling bond yields, the duration effect produces the result of higher prices of bonds and lower long-term interest rates[39].

[38] A bond's duration, often described as the Macaulay duration, is the weighted average time until all the bond's cash flows, including the nominal value of invested capital, are paid.

[39] It is important to notice that while the actions of a central bank in the form of the asset purchase program (APP) can take out from the market: (i) the liquidity risk (the risk of not being able to sell and buy bonds quickly on the market); (ii) duration risk (the risk of interest rate changes); and (iii) the exchange rate risk (if the euro-denominated bonds are held by non-Europeans, i.e., foreign investors); however, it cannot remove (iv) the credit risk (the risk of default of a bond's issuer). Thus, the APP is an effective instrument for removing all risk premia except for credit risk from the bond market. The pricing of these risks is, as a consequence, no longer managed solely by the market discipline, but partially by a large single buyer, that is, the central bank.

Thirdly, the large-scale assets purchases tend to affect long-term interest rates through a signaling channel. The announced programs of large asset purchases tend to have an immediate impact on the prices of bonds in the market. This fact is also presented in Figure 2.1, in which the central bank's forward guidance concerning the future amount of asset purchase programs affect not only market participants' expectations on the central bank's future actions but also their beliefs regarding the present stance of monetary policy, and as a result, it indirectly leads affect the level of long-term interest rates.

It is important to note that all three effects related to the unconventional (APP or QE-type) policies transmission are by no means mutually exclusive. Instead, they are most likely to operate simultaneously and to interact with each other. Ultimately, by easing monetary policy stance, each produces a similar final outcome, i.e. lowering long-term yields on a wide range of financial assets (Bailey, Bridges, Harrison, Jones, & Mankodi, 2020, p. 7).

It also needs emphasizing that the first two above-described effects, that is, scarcity and duration effects are often referred to, in the literature, as the portfolio rebalance channel, portfolio rebalance effect (Beyer et al., 2017; Fratzscher, Lo Duca, & Straub, 2014) or portfolio balance channel (Bernanke, 2010).

The last of the mentioned authors, Bernanke (2010), at the time serving as chairman of the Federal Reserve Board of Governors, described this specific channel as follows:

> "the so-called portfolio balance channel (…) [implies] that once short-term interest rates have reached zero, the Federal Reserve's purchases of longer-term securities affect financial conditions by changing the quantity and mix of financial assets held by the public. Specifically (…) [it] relies on the presumption that different financial assets are not perfect substitutes in investors' portfolios (…). For example, some investors who sold MBS to the Fed may have replaced them in their portfolios with longer-term, high-quality corporate bonds, depressing the yields on those assets as well" (Bernanke, 2010, pp. 7-8).

The portfolio rebalance effect is an important concept because it is strongly related to risk-taking channel, and so it does require further elaboration. First, a major consequence of the quantitative easing is fact that investors' portfolios are becoming safer. This objective can also be accomplished by the so-called 'credit easing' policy in which a central bank purchases some of the very risky and illiquid financial assets, often dubbed 'toxic' asset-backed securities. Thus, the central bank policy achieves the goal of reducing (releasing) some (excess) risk from the balance sheet and investment portfolio of banks and investors. This situation, combined with an environment of very low interest rates, allows both banks and other investors to take on again more risk (in the form of risky assets) on their balance sheet and investment portfolio. This risk-taking behavior can be observed as banks extend new credit to risky borrowers (the bank lending channel of the credit channel) or buy more risky assets (bidding up the prices), such as corporate bonds, stocks, or financial derivatives. All in all, banks with large amounts of excess reserves (which are proceeds from the central bank's asset purchase), in an environment of extremely low short-term and long-term interest rates, are naturally willing to search for yields, which means that their risk-taking behavior is again activated. Such behaviors necessarily affect the asset prices and can potentially lead to the wealth effect, as is presented in the right part of Figure 2.1. In recent years, this specific propagation channel of non-standard monetary policy impulses (balance sheet policy), that is the risk-taking channel, has gained much prominence[40] (Borio & Zabai, 2016; Borio & Zhu, 2012).

However, the portfolio rebalancing and risk-taking are only some of the operative channels of unconventional monetary policy. As long as the central bank engages in purchasing government securities, targeting the market for public sector debt, it thus conducts a so-called quasi-debt management policy. Based on the adopted taxonomy of unconventional monetary policy measures, such policy actions are most appropriately classified as a part of the broader public debt management policy[41] (Borio & Disyatat, 2009; Borio & Zabai, 2016). In this sense, Allen (2012) importantly pointed out that "quantitative easing is a form of debt management, and comparable with earlier debt-management actions" (Allen, 2012, p. 806). Using historical data, this author described four major periods in the UK's debt history in the twentieth century to demonstrate that

[40] An in-depth analysis of the risk-taking, and portfolio rebalancing channels along with the more elaborated inquiry into the credit channel of monetary transmission mechanism is a subject of Section 2.3 of the present dissertation.

[41] As these authors stress, one can „use the qualifier 'quasi' only to stress that the objectives may be quite different from those of debt management and to indicate that any change in bank reserves in this context is seen as a mere by-product of the transactions in government paper, with no independent impact of its own" (Borio & Zabai, 2016, p. 5).

the QE policy “is not at all unconventional. Debt management will continue to have macroeconomic importance […] and will therefore need to be coordinated with other aspects of monetary policy” (Ibid.)[42].

Central bank’s extensive purchases of government securities, being mostly Treasury bonds and bills or state-guaranteed debt instruments, such as bonds issued by the state-owned enterprises (SOEs) or housing-related government-sponsored enterprises (GSEs), ensures that market yields on these bonds will be partly controlled and kept at low levels. Otherwise, the market participants’ demand for these instruments could have not absorbed all the existing supply of the new bond issues of these entities. In this way, assets purchase programs, such as APPs or LSAPs or simply quantitative easing (QE) policy, through an expansion of the central bank’s balance works both as a means for the public sector debt management (Auerbach & Obstfeld, 2005; Chadha, Turner, & Zampolli, 2013) and as a financial-stability tool (Greenwood, Hanson, & Stein, 2016). As a result, the QE policy by exerting downward pressure on the yields of government securities helps to ease the tensions in the market for government long-term securities, and at the same time allows the cost of public sector spending to remain affordably low. This quasi-fiscal channel of the non-standard impulse propagation within the monetary transmission mechanism can be seen in the bottom-right part of Figure 2.1.

The quasi-debt management channel of unconventional monetary policy was empirically demonstrated to be effective and significant, especially in the low interest rates environment or in the famous Keynesian liquidity trap situation, in for example Auerbach & Obstfeld (2005), who focused on the case of Japan’s QE. These authors concluded that:

> “Our detailed numerical results suggest, moreover, that for Japan the fiscal benefits are large enough to overwhelm any reasonable fears about inflation, especially starting from a position where prices actually are falling. In other words, the government’s net debt is already so large that authorities should perceive very powerful fiscal incentives to end deflation. Following a

[42] In the similar vein, Allen (2017) calls for much closer and more cost-effective coordination between the monetary policy authority and fiscal policymakers in order to restore the Bank of England’s independence, “by transferring the gilts that the Bank has bought to the Debt Management Office of the Treasury and thereby shrinking the Bank’s balance sheet” (Allen, 2017). For a comprehensive account of the central bank’s role in the management of debt in the UK in the period 1928-1972, see Allen (2019).

> monetary increase that leaves some public debt outstanding, the authorities' incentive is for more of the same, rather than a reversal" (Auerbach & Obstfeld, 2005, p. 130).

Lastly, a non-standard monetary policy impulse in the form of a change in the amount of assets purchases usually tends to have an impact on the level of the exchange rate. In this regard, it is a similar channel to the one of interest rate policy-induced fluctuations in the exchange rate. The analogous is as follows. A reduction in the official interest rates causes short-term interest rate to decrease, and that in turn discourages foreign investors to invest or lend in the domestic short-term financial assets, which leads to domestic currency depreciation. Similarly, an expansion of asset purchase program, which causes bond yields to decrease, in turn leads foreign investors to withdraw their capital and close their financial positions in long-term domestic currency-denominated financial assets, all of which creates the downward pressure on the domestic currency exchange rate. Changes in the exchange rate, in this channel, naturally affects import prices because a depreciation of a domestic currency means higher prices of import (ECB, 2011, p. 75). On the other hand, a currency depreciation translates into the higher demand from abroad in the form of rising net export that, in turn, increases the aggregate demand in the country and can further intensify the inflation pressure (Beyer et al., 2017, p. 14).

2.3 Monetary policy and the credit channel

Bernanke (2007) distinguishes two separate credit channels of the monetary transmission mechanism, that is, the balance sheet and the bank lending channels (see also Bernanke & Gertler, 1995). This approach is regarded as the 'credit view' of the macroeconomy, and in particular, it is often referred to as the credit view of the monetary transmission (Boivin et al., 2010, p. 15). More detailed surveys and discussions of the credit channel of the monetary transmission and its original seminal contributors can be found in Bernanke (1993); Bernanke & Gertler (1995); Cecchetti (1995); and Hubbard (1995).

In recent years, however, the credit view approach to the monetary transmission mechanism has been enriched with and enhanced by a new, distinct and separate channel within it, namely the bank capital channel (Borio & Zhu, 2012; Markovic, 2006; Meh, 2011; Van den Heuvel, 2009). Consistent with this expanding body of literature, the bank capital channel is regarded in the present thesis as the third separate channel within the credit channel in the general monetary transmission framework (see Figure 2.1).

First, the traditional bank lending channel, consistently with Bernanke & Gertler (1995), is defined as a monetary policy influence on the "external finance premium by shifting the supply of intermediated credit, particularly loans by commercial banks" (Bernanke & Gertler, 1995, p. 40). Thus, the bank lending channel is crucially dependent on private banks' ability to overcome information asymmetry problems, and in effect, on them being able to supply credit to borrowers that they deem creditworthy.

The external finance premium arises whenever economic agents find themselves unable to raise funds cheaply though direct finance such as by raising capital, attracting deposits, or through retained earnings. Thus, they become bank credit-dependent entities and have to pay some sort of premium for obtaining external bank credit. Such model of financial system is often described as the bank-based model (intermediated finance) as distinct from the market-based model (direct finance). The reason why agents have to pay some level of premium over the market cost of finance is that banks face the information-asymmetry related problems, such as negative selection, moral hazard (i.e., increasing agency costs) above and beyond the usual costs associated with credit, liquidity and maturity risks. In this situation, banks necessarily have to engage in some specific and costly activities, such as screening bad credit risks, monitoring of borrowers, and enforcement of credit contracts and restrictive covenants (Bernanke & Gertler, 1995; Mishkin, 1991).

Standard monetary policy impulses in the form of changes in the rate of interest is propagated via the bank lending channel (within the credit channel) in three distinct ways. First, a reduction in the central bank (official) rate of interest, even if only partially transmitted to bank lending rates, allows firms and households to obtain credit and loans from commercial banks less costly (a direct price effect). Second, a decrease in the money-market short-term rates, through revaluation channel (i.e., market participants' trading) affects the prices of financial instruments in the capital market (e.g., stocks and bonds), causing them to rise. Elevated market values and an increased net worth of corporates (stocks) allow firms to borrow more, as they now are able to pose larger collateral against the borrowed credit. More valuable and solid collateral, in turn, also tends to alleviate the negative asymmetric information problems, such as adverse selection and moral hazard. As a result, the external finance premium shrinks, and in this situation, banks may be willing to extend more credit to a wider range of potential borrowers (an asymmetric information effect). Thirdly, an interest rate decrease usually translates into lower debt service expenses to income (DStI) ratios, which tends to lower the share of non-preforming loans (NPLs), allowing banks to reduce the amount of loan loss provisions (LLPs), which in the end, increases the gross income and profits of banks[43] (profitability effect)[44].

The second separate credit channel of the monetary transmission mechanism is the bank balance sheet channel. The balance sheet channel of the monetary policy is related to the composition, strength, and risk profile of balance sheets of banks and banks' borrowers (Borio & Disyatat, 2009, p. 5; Disyatat, 2011, p. 711). Consistent with Disyatat (2011) reformulation of the bank lending channel, Kapuściński (2017) emphasized that "a monetary impulse can reduce loan supply through its impact on bank balance-sheet strength" (Kapuściński, 2017, p. 51). Similar to bank lending channel, the balance sheet channel operates through the presence of asymmetric information problems in credit markets, which itself provides grounds for external finance premium. Importantly, as suggested and argued in Disyatat (2011), costs of obtaining the external finance reflect changes in bank health at an institution level as well as changes in monetary policy stance at the system-wide level[45] (Disyatat, 2011, p. 731).

Consistent with the 'picking order' theory of corporate finance, the balance sheet channel posits that firms with strong balance sheets, which means that they have "a high net worth and plenty of liquid assets" (Bernanke, 1993, p. 54), are the most likely to rely on the internal finance (such as cash or retained earnings) instead of external finance (such as bank loans or debt instruments) to fund their capital investment. However, due to a severe deterioration of firm and households' balance sheets that involve a high share of debt in their funding structure, a low value of net worth and of collateral, and falling

[43] It must be stressed that a decrease in the rate of interest, which works through the lower agency costs and lower bank provisions will only produce a positive effect on bank profit if at the same time, the banks' interest income is not severely reduced, as a consequence of lower cup (limit) on the maximum loans rate.
[44] For more discussions of the standard bank lending channel, see Bernanke (1993); and Gambacorta (2005).
[45] Disyatat (2011), in his revisited version of the standard bank lending channel, focused on "financial frictions at the level of financial intermediaries and how policy-induced variations in their external finance premium is reflected in the cost of funds to borrowers that are dependent on these institutions" (Ibid., p. 712). In this reformulated framework, "[q]uantitative constraints on bank lending, such as the level of deposits or reserves, are greatly de-emphasized. Such a recasting of the bank lending channel has been articulated by Bernanke (2007)" (Ibid.).

values of equity capital (in the case of listed firms), their financial positions become fundamentally different. In other words, whenever the banking (and also the corporate) sector becomes highly leveraged, their balance sheets weaken and the monetary transmission is changed. There is a number of factors involved in this process. First, in line with a notion of the balance sheet recession proposed by Koo (2011, 2013), in economic downturns agents may wish to deleverage (instead of taking another bank loan), paying off their previous debts and so may be simply unwilling to borrow. Banks, on the other hand, can also become pessimistic and very conservative in their lending to such (highly leveraged) economic agents, especially in the peak or shortly after the peak of business (and credit) cycle. This situation of the international phase of debt deleveraging was the case in point in the years of the Great Depression of 1930s and also in the years following the 2007-2009 Global Financial Crisis, and the ensuing period of Great Recession (see e.g., Fornaro, 2018; Mian, Rao, & Sufi, 2013; Mishkin, 1978).

The other aspect of balance sheet channel of monetary policy within the credit channel is the transmission of the central bank's impulses through the bank capital and the strength of banks' balance sheet (as a separate channel from the balance sheets of firms and households). This channel involves many complicated interactions that can occur between bank equity capital, international capital adequacy regulations, and the bank balance sheet.

A simple accounting example will suffice to illustrate the point. According to Basel III framework (see BIS, 2017; Roulet, 2018), banks are required to hold the minimum capital requirement at 8% for the ratio of total regulatory capital to total risk weighted assets. Assuming that a bank has 100 million of risk-weighted assets (RWAs) and holds the exact amount of 8 million in (total) capital, it fulfils the 8 per cent requirement for the total capital ratio. If the bank faces a capital loss equal to 1 million, because of increased share of non-performing loans, a reduction in loans – required to maintain 8% of capital ratio – must be equal to the size of its capital loss scaled up by the inverse of the bank's capital ratio (1 divided by 8%, that is 12.5). As a result, the assets of the bank weighted by risk factors has to be reduced by 12.5 million (1 million multiplied by 12.5). In other words, the bank's total RWAs now have to decline to 87.5 million. In this situation, a significant deterioration in the strength of balance sheet of the bank (caused by heighted loan losses) may strongly incentive it to reduce its assets in the sudden manner, which is otherwise known as a fire sale of assets. A more costly and time-consuming process would be to raise the additional 1 million of capital by a new shares issue to be sold in the market or through a private placement (Carlson et al., 2013).

In the above example, the crucial aspect determining bank behavior is a combination of three usually analyzed separately factors, that is: (i) worsening financial conditions that lead to a significant capital loss in the bank capital, (ii) strict capital regulations that banks must comply with, and finally (iii) the balance sheet strength – all of which combined can determine the bank's ability to raise capital and also bank's willingness to grant new loans and credit (i.e., the traditional bank lending channel). In summary, the conclusion of the above discussion is well captured by Bernanke (2007) who recognized that "fundamentally, the bank-lending channel is based on changes in the quality of bank balance sheets". Therefore, as he further noted, this fact "naturally turns our attention to bank capital and its determinants". Importantly, this view is in line with a large body of recent empirical studies and also with some early influential works, such as Van den Heuvel (2002). The empirical evidence of the unconventional monetary policy impact on bank lending through the bank capital channel is the subject of Section 2.5 of the present thesis[46].

2.4 Bank risk-taking and portfolio-rebalancing effects

An important question arises whether the credit channel of monetary transmission of the non-standard monetary policy measures is affected, and if so to what extent, by observed two effects related to asset purchase programs, namely the bank risk-taking and portfolio-rebalancing effects.

I will first analyze effects related to the bank risk-taking channel. Above all, this channel represents varying and most likely procyclical changes in "banks' perceptions of, and attitude towards, risk" (Gambacorta, 2009, p. 43). In relation to the emergence of this new transmission channel of monetary policy, Borio & Zhu (2012) pointed out that "insufficient attention appears to have been paid so far in the transmission mechanism to the link between monetary policy and the perception and pricing of risk by economic

[46] For more details and theoretical underpinnings of the bank-capital channel of the transmission of conventional monetary policy, see Meh (2011) and Van den Heuvel (2002, 2009). For a specific theoretical model of this channel of transmission of the monetary policy, see Honda (2004).

agents" (Borio & Zhu, 2012, p. 237). Consequently, these authors insisted to call this new channel "a missing link in the transmission mechanism" (Ibid., p. 236).

The risk-taking channel is the field of the intersection between the traditional interest rate policy, namely setting official rates close to zero, and the unconventional measures that belong to balance sheet policies, which is not unexpected, given its emergence only in recent years. More specifically, as the monetary policy report of the ECB (2011) stressed:

> "(…) risk-taking channel may exist when banks' incentive to bear risk related to the provision of loans is affected. The risk-taking channel is thought to operate mainly via two mechanisms. First, low interest rates boost asset and collateral values. This, in conjunction with the belief that the increase in asset values is sustainable, leads both borrowers and banks to accept higher risks. Second, low interest rates make riskier assets more attractive, as agents search for higher yields" (ECB, 2011, pp. 60-61).

A question arises how market participants know whether some specific increases in asset values will be sustainable in the future. First, it may be the case because central bankers have adopted a new tool of managing market participants' expectations which is forward guidance. In the post-crisis period, central banks have begun to communicate that their official interest rates will be kept at low level for some long time, usually referring to an "extended period". Similarly, they often decided to adopt "open-ended" asset purchase programs, or at least, indicating *a priori* the future date that they reckon their programs should end, often also conditioned on the future state of the economy (see Borio & Zabai, 2016, pp. 8-9, and p. 16). Secondly, APPs can indeed be treated as signals for market participants about the central bank's present and future stance from the forward-looking perspective. As argued by Borio & Zabai (2016), "investors may consider a large-scale government bond purchase as a signal that the central bank will keep the policy rate low for longer, which would naturally lower the yield on the bond" (Borio & Zabai, 2016, p. 10).

Gambacorta (2009) refers to two main mechanisms through which monetary policy impulses can be transmitted through the risk-taking channel to the financial sector and to the real economy. First, by the familiar impact of interest rates "on valuations, incomes and cash flows, which in turn can modify how banks measure risk", and secondly, "through a search for yield process, especially in the case of nominal return targets" (Gambacorta, 2009, p. 43). As the first mechanism has been exposed in Section 2.2 and also was already explained above in the paragraph on the standard bank lending channel, I will next focus on the search for yield mechanism.

In an environment of very low level of the official short-term interest rates, central banks' asset purchase programs (APPs) seem to complement, broaden and enhance the impact of the zero-interest rate policy on a wider spectrum of financial instruments, including long-term debt instruments, such as the government debt (Treasury bonds and bills), corporate bonds and papers and asset-backed securities (ABS). All of which works to produce the same effect, that is, central banks implementing the near zero-interest rate policy on the very wide scope of financial and capital instruments, above and beyond targeting and influencing the price of standard monetary policy instruments, such as central bank bills, the standing facility, refinancing (and repo) operations, etc. Thus, central banks can now target, affect and to a large extent effectively control the price and yields of these assets. This monetary policy strategy is sometimes depicted as the yield-curve targeting or the yield curve control[47].

In an environment of low interest rates on a wide spectrum of financial assets, a majority of investors, banks, pension funds, hedge funds, and insurance companies (in short, 'investment managers' – to borrow a term from Rajan (2005) – or 'money managers' to borrow a term from Minsky (1986) – see Wray (2011), or to put it simply, 'portfolio managers') have tried to target the nominal total return on the managed assets in an endeavor that has become much harder in the post-crisis period. As pointed out by Gambacorta (2009), this "inertia in nominal targets" in the low interest rate environment may be caused by a number of factors:

> "Some are psychological, such as money illusion […] Others may reflect institutional or regulatory constraints. For example, life insurance companies

[47] A strategy of explicit yield curve control was adopted by the Bank of Japan (BOJ) already in 2016, see BOJ (2016). In the Bank of Japan's pioneering framework of "Quantitative and Qualitative Monetary Easing with Yield Curve Control" it is assured that "the Bank will control short-term and long-term interest rates" (BOJ, 2016, p. 1). More recently, in the official "Statement on Monetary Policy" released in July 2020, Bank of Japan still maintains that "[t]he Bank will purchase a necessary amount of Japanese government bonds (JGBs) without setting an upper limit so that 10-year JGB yields will remain at around zero percent" (BOJ, 2020, p. 1).

> and pension funds typically manage their assets with reference to their liabilities. In some countries, liabilities are linked to a minimum guaranteed nominal rate of return or returns reflecting long-term actuarial assumptions rather than the current level of yields. Such minimum returns may be fixed by statute […]. In a period of declining interest rates, they may exceed the yields available on highly rated government bonds. The resulting gap can lead institutions to invest in higher- yielding, higher-risk instruments" (Gambacorta, 2009, p. 44).

Both institutional, regulatory, and indeed even psychological factors can explain the process of money managers searching for high yields, as highlighted above. Portfolio managers effectively seek to take more and more risk while investing at the same time in more and more complicated, opaque and risky financial instruments (see also Borio & Zhu, 2012). As a result, the risk-taking channel of the traditional interest rate policy gets aggravated and amplified by asset purchase programs (as a part of balance sheet policies) that not only keep interest rates on many debt instruments very low, but also supply banks with ample amounts of excess reserves[48]. These reserves are usually remunerated at the key policy rate, at deposit facility rate or at the interest rate on excess reserves (IOER) – all of which are very close to zero or in some cases even negative[49].

In addition to targeting nominal returns, banks, and especially investment banks, and other financial corporations and investment funds also target nominal value of leverage (Adrian & Shin, 2010a). These researchers found strong empirical evidence that points "to financial intermediaries adjusting their balance sheets actively, and doing so in such a way that leverage is high during booms and low during busts" (Adrian & Shin, 2010, p. 419). In other words, they found that financial leverage, defined as a ratio of total assets to equity capital (own funds), has been procyclical in the period before the financial crisis. The analysis of data from period 1963-2006 leads these authors to conclude that bank engage in "active management of balance sheets (…) [in response] to changes in prices and measured risk" (Ibid., p. 419). The evidence, moreover, provides "outward signs of commercial banks targeting a fixed leverage ratio" (Ibid., pp. 420-421).

[48] This process is somewhat similar to amplifying dynamics and accelerating effects suggested by the financial accelerator theory.
[49] For example, in June 2020 the IOER in the United States was equal to 0.10% and in Europe the ECB's deposit facility rate was negative and equaled -0.50%.

Furthermore, the study of Adrian & Shin (2010) shown that, in principle, when securities prices increase (leading to higher profits and increased capital positions) banks in order to maintain a fixed leverage target will simply take on more debt to purchase even more of securities. Analogously, faced with falling securities prices, because of a decline in the equity capital, banks will have to sell assets on a massive scale during stressed periods (often in the rapid manner, i.e., fire sale of assets) to achieve their level of target for the leverage ratio. Such behavior of banks and asset portfolio managers, inevitably leads to the procyclical leverage. In other words, the empirical relationship between changes in the size of balance sheets and in the level of leverage is found to be significant and positive. Thus, banks responding to price changes by actively adjusting their balance sheets to hit the leverage target will "reinforce each other in an amplification of the financial cycle" (Ibid. p. 423). This is an observation that relates itself back to the financial accelerator body of literature (e.g., with the seminal works of Bernanke & Gertler, 1989; Bernanke, Gertler, & Gilchrist, 1996). In summary, the fact that an increase in the prices of assets, which boosts profits and strengthens bank equity capital, in effect prompts banks to increase the size of their balance sheets and to adjust their leverage ratios. It is an important empirical observation also from the theoretical perspective.

Relatedly, investors and assets managers and banks in general in order to maintain the nominal return target (i.e., the targeted nominal profit margin) on their assets have to actively search for high yields and engage in different trades in the hope of purchasing risky but high-yielding and more profitable financial assets. This, however, does not mean that banks are interested in originating new and risky credit to the real economy. Instead, they are willing to seek for highly profitable debt instruments. They can hedge risks associated with them by buying, e.g., credit default swaps (CDS) which are not available to hedge for an individual credit risk related to some small idiosyncratic loan. Second reason why the risk-taking behavior of banks does not necessarily lead them to increase bank lending is a restriction put on the maximum loan rate that banks can charge in this new environment of very low interest rates. For example, in many countries the regulatory framework includes some anti-usury laws that forbids the so-called predatory lending and, in effect, puts the cup (the maximum limit) on the lending rates, limiting them usually with reference to official interest rate that is set by the central bank. Finally, bank risk-taking suggests a shift from providing credit and originating new loans towards structured, synthetic and often opaque financial instruments, which serve the purpose of hedging financial risks, in the form of financial swaps, derivatives, or collateralized debt obligations (CDOs).

The last point of this section concerns the so-called portfolio rebalancing effect. As was briefly explained above, the additional (excess) bank reserves that proceed from the asset purchase programs produce the portfolio rebalancing effect in two ways. In the first place, very risky financial assets are effectively removed from a bank balance sheet. In the second place, central bank's purchases take out a large amount of government bonds from the investors' portfolios. Specifically, the portfolio rebalancing effect consist of three distinct effects: scarcity effect, duration and signaling effects (IMF, 2013, p. 10).

The scarcity and duration effects relate to microstructure phenomena observed in the bond markets[50]. The central bank is reducing the amount of bonds available in the market, so their respective prices tend to increase, as some banks may still desire to keep them in the trading portfolio simply as a buffer stock or a regulatory stock of the government debt. The underlying motive is, firstly, that these relatively less risky (government guaranteed) instruments can serve as a collateral in both repo and buy-sell-back transactions. Secondly, securities issued by the Treasury have very low risk weights so that they do not necessarily translate into higher capital requirements. Thirdly, in some countries, government bonds are exempted from some specific bank levy. All three effects combined cause the central bank's purchases to crowd out the market participants' demand, and thus increase the price and decrease the yields of the purchased bonds (Beyer et al., 2017; Han & Seneviratne, 2018).

The central bank through its assets purchase programs is effectively taking away not only some part of the risk premium from market prices (when it purchases the risky, privately issued securities) but also the duration (i.e., term) premium when the central bank targets to buy outright long-term government bonds using the central bank reserves to pay for it. In short, it is in effect swapping the long-term public debt (Treasury bonds) for the short-term public debt (central bank reserves). The third effect, that is signaling of its intentions and informing on the executed operations only strengthen the scarcity and duration effects of asset purchase programs.

[50] For more details and discussion of empirical microstructural aspects of asset purchase programs and of the QE policy in the bond markets in particular, see e.g., Boermans & Keshkov (2018); Ferdinandusse, Freier, & Ristiniemi (2020); Schlepper, Hofer, Riordan, & Schrimpf (2020); Van den End (2019).

In summary, the portfolio-rebalancing effect is, on the one hand, a part of the quasi-debt management policy because APPs ensure that all new issues of public-sector debt are fully absorbed by the market (or by the central bank). On the other hand, it also operates through the risk-taking channel as it contributes and significantly impacts the investors' risk-taking behavior (Borio & Disyatat, 2009). In an environment of very low interest rates and amid vast amounts of excess bank reserves, investors' risk-taking behavior in the form of search for high yields (without contributing to new loans origination as banks may in fact employ credit rationing strategies) might in many cases be a strictly preferred investment strategy.

2.5 Monetary policy and its effects on lending in empirical evidence

In this section, I will focus on empirical evidence of the effects of conventional monetary policy on bank lending. It is worth beginning with some empirical observations present in the literature on bank-lending channel and bank capital channel that focused on the individual bank effects of the conventional monetary policy.

In an important early study, Kishan & Opiela (2006) focused on conventional monetary policy effects separately on the loan behavior of low-capital and high-capital banks in the US. Their area of research thus covers the intersection between the bank-lending channel of conventional monetary policy, capital regulatory policies and the bank-capital channel. They distinguished between:

(i) cross-sectional asymmetry that causes different policy effects on the loan supply of capital-constrained and unconstrained banks for a given stance of monetary policy. The asymmetric response in bank lending stems from individual bank characteristics (i.e., the cross-sectional variation); and

(ii) policy-stance asymmetry that is a source of different effects of contractionary and expansionary monetary policy on bank lending for a given level of bank capital. In this case, an asymmetric response in bank lending is a result of different effects of expansionary and contractionary monetary policy, controlling for an interest rate change of the same magnitude (Kishan & Opiela, 2006, pp. 264-265).

More specifically, the evidence provided by Kishan & Opiela (2006) suggests that small and low-capital banks tend to decrease their lending activities more in response to contractionary conventional monetary policy in comparison to high-capital banks. Expansionary monetary policy is, however, unable to induce the loan growth of the low-capital banks relative to the high-capital banks (Kishan and Opiela, 2006, p. 282). In other words, according to this study, the size of a bank and the initial level of capital ratio is crucial for bank's responsiveness to conventional monetary policy shocks. In particular, they concluded that "[conventional] monetary policy has the expected impact on the loan growth of the small low-capital banks. That is, contractionary monetary policy decreases the loans of the small low-capital banks relative to high-capital banks, and expansionary monetary policy is not able to increase the loan growth of the low-capital banks relative to the high capital banks" (Ibid.)

In an earlier empirical examination of the bank lending channel, Kashyap & Stein (2000) found that the impact of conventional monetary policy on lending is stronger for US banks with less liquid assets on their balance sheets, i.e., for banks with lower ratios of liquid securities to assets. Thus, they also demonstrated an important role of "cross-sectional differences in the way that banks with varying characteristics respond to policy shocks" (Kashyap & Stein, 2000, p. 407). They concluded that this pattern is mostly attributed to smaller banks whose ratio of credit to total assets is relatively large so that their balance sheets are more illiquid compared to balance sheets of large banks.

The previous empirical research of these authors, particularly the findings of Kashyap & Stein (1994) are largely in line with the above indicated conclusions. The study of Kashyap & Stein (1994) demonstrated that it is small-bank loans and small-bank securities holdings that are most "sensitive to [conventional] monetary policy" compared to the respective balance sheet items of large banks (Kashyap & Stein, 1994, pp. 38-39).

In the euro area, the conventional monetary policy effects on bank lending have been empirically studied by De Bondt (1999) and Ehrmann, Gambacorta, Martínez-Pagés, Sevestre, & Worms (2001). The first study, conducted shortly before the adoption of the single European currency, the euro, found that "monetary policy in continental Europe matters most for small banks and for banks with relatively illiquid balance sheets (bank lending channel)" (De Bondt, 1999, p. 163). Thus, in this respect the finding of De Bondt (1999) study is consistent with the previous US related literature. The size and degree of liquidity of banks matter for their reactions to changes in monetary policy stance. However, the European results differ with regard to one crucial aspect, namely there is no homogenous bank lending effects for all studied European countries. De Bondt (1999) reported the following results:

> "All empirical results provide evidence for the existence of a bank lending channel in Germany and the Netherlands. For Belgium the empirical support for the existence of a bank lending channel seems to be driven by the smallest banks. In France and Italy there is only empirical evidence for the existence of a bank lending channel (…) The empirical results provide strong evidence for the existence of a balance sheet channel in Germany and to a lesser extent also in Italy. No empirical support for the existence of credit channels in the United Kingdom is found" (De Bondt, 1999, pp. 163-164).

A crucial insight of this study is therefore the importance of cross-sectional country-specific heterogeneities in the monetary transmission within a broad credit channel, i.e. including the bank lending and balance sheet channels, in the studied European countries. As De Bondt (1999) stressed, "[g]iven the bank-oriented financial systems, particularly in continental Europe, the cross-sectional differences in bank lending behaviour are large enough to be potentially of importance for aggregate economic dynamics" (Ibid., p. 164).

The starting point of Ehrmann et al. (2001) study is similar to the one of De Bondt (1999). These authors from the beginning noted that "heterogeneity of the market structure of the banking industry across euro area countries" is an important consideration (Ehrmann et al., 2001, p. 8). Furthermore, they acknowledged some significant differences between the transmission mechanism in the US and in the euro area. Namely, they stated "most European countries rely much more heavily on bank finance than for example the US" so the bank lending channel can significantly differ in these two areas (Ehrmann et al., 2001, p. 7). They also argued that information asymmetry problems which make small banks more sensitive to a monetary policy tightening are of less importance in Europe (Ibid.). Particularly, Ehrmann et al. (2001) pointed out that "[b]ank characteristics like size that proxy informational asymmetries should not be particularly revealing in most of the euro area countries" (Ehrmann et al., 2001, p. 20). They noted that in countries like Austria or Germany where bank networks or government-owned banks are dominant or in Finland where banks usually form large banking groups or unions informational asymmetries with respect to bank size should not be significant (Ibid.). Nonetheless, they considered the size of a bank ("measured by the log of total assets") in their baseline models. Furthermore, they included two other bank-specific characteristics, that is, the bank liquidity ratio ("measured as cash, interbank lending and securities to total assets") and the bank capital ratio, which is 'capitalisation' defined as "the ratio of capital and reserves to total assets" (Ehrmann et al., 2001, p. 23). It is important to underline that De Bondt (1999) defined the liquidity ratio as "liquid assets [divided by the sum of total] deposits and money market funding" (De Bondt, 1999, p. 153). Thus, it somewhat differs from the definition of liquidity adopted in Ehrmann et al. (2001, p. 23).

The study of De Bondt (1999) and of Ehrmann et al. (2001) bear some important similarities. Above all, they both used Bankscope database as the main source of bank-level data for their empirical models, which is also the case of the present thesis. Although, it must be stressed that Ehrmann et al. (2001) used also national (Eurosystem) datasets which they consider superior to annual Bankscope data as "evidenced by the improved explanatory power of the models and the better significance and robustness of results" (Ehrmann et al., 2001, p. 32). Importantly, they added that "[t]he publicly available database BankScope, used in similar studies to date, suffers from a representation bias. Since small banks are not covered adequately (…)" which used to be a fair point of critique back in the late 1990s and early 2000s.

With various data sources used, the study findings of Ehrmann et al. (2001) can be regarded as well founded. A general conclusion reached by these authors is that European banks on average reduce their lending activities after a tightening of monetary policy. Specifically, based on Bankscope data on individual banks in all euro area countries, they found that "the average bank reduces lending after a monetary tightening by 1.3% following a 100 basis point increase in interest rates. Smaller banks, however, reduce their lending by more than large banks do" (Ehrmann et al., 2001, p. 27). The above conclusion does not seem controversial: small banks facing higher costs of attracting funds, may be willing to curtail their lending in the situation of tightened monetary policy and falling corporate net worth and declining asset prices. In the general case, however, the authors found the capitalization ratio to be insignificant and liquidity coefficient to be unstable, leading them to accept a conclusion of the relevance of cross-sectional heterogeneity (Ibid.).

Using national datasets for each of the four largest euro area countries (France, Germany, Italy, and Spain), these authors confirmed the robustness of previous results, namely that “[t]he long-run effects of monetary policy on loans of an average bank are estimated to be negative in all countries, indicating that restrictive monetary policy reduces loan supply” (Ehrmann et al., 2001, p. 29). However, this time the results show that “size does not emerge as a useful indicator for the distributional effects of monetary policy” partly because of the structure of the European banking systems where “the role of size as an indicator of informational asymmetries appears irrelevant […] which is consistent with the structure of the banking market” (Ibid.). Moreover, the capital ratio also appears to be an insignificant driver of monetary policy (distributional) effects on bank lending[51]. These results pointing to insignificance of bank size and capital ratios are contrary to findings for US, as described earlier in this Section. It can be explained by the fact that information asymmetry problems may be less severe for European financial systems (Ibid., 36) or that the more complex European banking landscape requires perhaps a different research approach.

On the other hand, Ehrmann et al. (2001) found the other bank-specific characteristics, that is, a liquidity ratio to be a significant driver of distributional effect of monetary policy on lending “across banks in Germany, Italy and Spain” – that is in the three out of four studied countries (Ibid., p. 31). Importantly, “[i]n the specifications with all three bank characteristics, the degree of liquidity dominates the other characteristics for those countries, and now becomes the significant and dominant characteristic also for France”, as the researchers explained (Ibid.). The importance of “the positive coefficient on the interaction of the monetary policy indicator with the degree of liquidity” is that it translates into a conclusion that “less liquid banks show a stronger reduction in lending after a monetary tightening than relatively more liquid banks do” (Ehrmann et al., 2001, p. 32) which is identical to the conclusion reached by Kashyap & Stein (2000, p. 407)

[51] As the authors explained, there can be multiple reasons for this result. “For example, the measure of capitalisation we use could be too crude to capture the riskiness of a bank, and is thus not indicative for the informational asymmetry problems. This could very well be the case, since our capitalisation variable is derived from balance sheets without considering the structure of the loan portfolio or its risk characteristics. It might therefore not be capturing a risk-based measure like the Basel capital requirement” (Ehrmann et al., 2001, p. 29).

and is consistent with the observed cross-sectional asymmetry documented in Kishan & Opiela (2006, p. 264). In conclusion, Ehrmann et al. (2001) stated that the significance of bank liquidity may stem from the fact that “banks with more liquid balance sheets can use their liquid assets to maintain their loan portfolio and as such are affected less heavily by a monetary policy tightening” (Ehrmann et al., 2001, p. 32).

It must be stressed that there is a number of other pre-crisis empirical studies that seem to support a hypothesis that for a given level of strength of the bank balance sheet and under given macroeconomic context, undercapitalized banks, or more generally banks with low capital ratios, are more responsive to conventional monetary policy. This observation is reported for many developed economies. In particular, authors such as Kishan & Opiela (2000, 2006) in the US, Altunbas, Fazylov, & Molyneux (2002) in the euro area, and Gambacorta (2005) in the context of Italian banks, empirically support the notion that banks with low capital ratios are more sensitive to conventional monetary policy adjustments.

2.6 Summary and Hypotheses

The next paragraphs focus on a brief review and summary of the literature on the effects of monetary policy’s unconventional measures in the form of ECB’s QE on bank lending activities in Europe. Based on this summary, empirical hypotheses are formulated.

According to the study of Horst & Neyer (2019), the increased excess reserves and deposits that resulted from the ECB assets purchase program “have no or even a contractionary impact on bank loan supply” (Horst & Neyer, 2019, p. 231). The proposed explanation behind this observation is the fact that very large excess reserves and deposits held by banks cause them to face rising marginal costs related to agency problems (moral hazard problem) and regulatory issues, such as a costly threat of not complying with the minimum capital requirements and regulations (Ibid.). In this light, banks could be forced to halt their lending in order to reduce the QE-induced ‘balance sheet costs’. A similar line of argument and evidence were provided in the study of Martin, McAndrews, & Skeie (2016) who also found that the large QE-induced excess reserves can actually have contractionary rather than expansionary effects on bank lending (Martin et al., 2016, p. 217). The reason for this is that banks may face increasing costs due to “the size of their balance sheets because of agency costs or regulatory requirements on capital or leverage" (Ibid.).

In addition, as reported by Demertzis and Wolff (2016), the effect of the ECB's QE policy on bank profitability has not been unidirectional and only positive (Demertzis & Wolff, 2016, p. 1). The bank profitability was affected by the QE in three distinct ways, all leading to different conclusions (Ibid.). Firstly, as the QE increases the demand for bonds, leading to higher bond prices, banks that hold them experience their balance sheet strengthening. Secondly, as the bond purchases depress long-term bond yields, the term spread between bank lending and deposit narrows down, and as a result, the net interest income on new loans decreases. Thirdly, as this unconventional monetary policy measure should in principle improve the economic outlook, the expected bank profits could also rise, while the amount of non-preforming loans and loan loss provisions decrease (Demertzis & Wolff, 2016). However, this last effect may not dominate the other two.

To sum up, the impact of Quantitative Easing policy of the ECB that results in increasing balance sheet costs and stable or falling bank profits may have caused bank lending to decrease independently of any changes to bank capital ratios. In line with this argumentation, I can formulate the first empirical hypothesis as follows:

> H1: *the effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB*

Taking into consideration bank-specific characteristics, however, can generate different results and point to different conclusions. As demonstrated by Kim & Sohn (2017) and Ehrmann et al. (2001), the relative liquidity position of particular banks matters for sign and strength of the link between bank capital and loans growth. Kim & Sohn (2017) provided evidence that large banks with sufficient level of liquid assets are characterized by a positive relationship between their capital ratio and the loans growth. In particular, they reported that "bank capital exerts a significantly positive effect on lending only after large banks retain sufficient liquid assets" (Kim & Sohn, 2017, p. 95). The results of a study by Thornton & Tommaso (2020), who analyze the liquidity effects on bank capital and lending link for European banks, are consistent with and confirm the previous findings of Kim & Sohn (2017) for the US banks. Thornton & Tommaso (2020) found that the effect of bank capital ratios on the growth of credit and lending by

European banks crucially differs depending on the level of the relative liquidity. They concluded that capital ratios exert a positive effect on European banks' lending growth "only after they retain sufficient liquid funds" (Thornton & Tommaso, 2020, p. 6).

In line with this evidence, I can formulate the second empirical hypothesis:

> H2: *the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for large banks with sufficient level of liquidity*

The similar view which takes into account the bank-specific heterogeneity in measuring the response of bank lending to the shocks to bank capital ratio has been also expressed in the early study of Joyce & Spaltro (2014) for the UK banks. These authors found evidence that the QE effects on bank lending were heterogonous across banks. Moreover, they reached a conclusion that bank lending is in a significant way positively related to bank capitalization, "suggesting that the impact of QE on bank lending may have been weaker because of the lower levels of capital during the crisis" (M. S. Joyce & Spaltro, 2014, p. 18). Linking this evidence with the previous findings, I can derive the third empirical hypothesis which is as follows:

> H3: *the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for well-capitalized banks with sufficient level of liquidity*

The impact of Quantitative Easing policy on the relationship between bank capital ratios and lending can also depend on various country-specific variables such as capital regulatory restrictions and other restrictions imposed on banks in different countries. For example, an empirical study of Martins, Batista, & Ferreira-Lopes (2019) has provided evidence that in countries that were hit the most by the recent financial and economic crises, such as Italy, Greece, Portugal, Spain, and Cyprus, the elasticity of loans to general governments with respect to ECB purchases under the PSPP were even 28 times higher than in other countries (Martins et al., 2019, p. 1219).

The importance of both liquidity and capital regulations for examining the effects of capital on European bank lending was previously stressed by Roulet (2018). Importantly, this researcher found that "more stringent capital adequacy rules encourage substitution out of retail-and-other loan assets into risk-free, more liquid government bond securities” in the post-crisis period (Roulet, 2018, p. 28). Consistently with this evidence, one can expect that banks from countries with more restrictive capital regulations that were subjected to APP purchases by the ECB could have significantly curtailed their bank lending and replaced it with notably less risky government bonds. Therefore, the expected empirical mechanism at play is that more stringent capital regulations can negatively affect the capital effect on bank lending. Accordingly, the fourth empirical hypothesis of the present thesis reads as follows:

> H4: *the effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB only for banks from countries characterized by more restrictive capital regulations and more stringent overall restrictions on banking activities*

Lastly, considering the fact that the largest program in the European Central Bank’s APP package of unconventional large-scale asset purchases has been the Public Sector Purchases Program (PSPP), it can be argued that banks operating in a banking system of some specific structure can be more prone to both capital and regulatory constraints while also being more likely exposed to the ECB’s PSPP. In the literature exists several explanations why banks that operate in highly concentrated banking systems could be more responsive in lending to shocks to their capital adequacy ratios. First, as argued by Marshall & Rochon (2019), more concentrated structure of the banking sector is associated with prominence of the so-called Too Big To Fail (TBTF) banks whose a market position allows them to take excessive risks in financial market, having at the same time low or, in some cases, even not sufficient level of equity capital. TBTF banks have thus had incentives to operate at the low level of capital because at any time they could be rescued by capital injections (i.e., recapitalization) as a part of the state aid. A similar mechanism can in theory operate in banking sectors with high share of large state-owned banks that are more likely to hold public sector securities and thus are more exposed to QE programs such as the ECB’s Public Sector Purchase Program.

In this light, the QE policy which leads to improving liquidity conditions, could also make banks more capital-constrained, and thus could be positively associated with the effect of bank capital ratios on bank lending. Consequently, the fifth empirical hypothesis of the present thesis is as follows:

H5: *the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for banks from countries characterized by more concentrated structure of the banking sector and higher share of state-owned banks*

The above five empirical hypotheses formulated in Chapter 2 along with research questions stated in Chapter 1 will be empirically verified based on applied econometric models in Chapter 4.

Chapter 3. Methodology

3.1 Empirical methods

An empirical method applied in the research consists in estimating standard panel data models. In the first place, this study employs fixed effects panel method, as a common solution to the problems that might be encountered with this type of financial data. The fixed effects modeling is viewed as being "used more frequently in economics and political science, reflecting its status as the 'gold standard' default" (Bell & Jones, 2015, p. 133). Similarly, Schunck (2013) claims that "[i]t is widely recognized that fixed-effects models have an advantage over random-effects models when analyzing panel data because they control for all level 2 characteristics [i.e., variables that vary only between groups or clusters], measured or unmeasured" (Schunck, 2013, p. 65). Particularly, one of the major benefits of the fixed effects method, applied using either the within-groups or the between-groups approaches, is that it allows researchers to avoid the unobserved heterogeneity bias. The bias itself stems from the omitted variable problem commonly arising in the panel data models (Dougherty, 2011, p. 514).

The first panel data model that I apply to determine factors that significantly influence the impact of the ECB's quantitative easing policy on the relationship between bank capital and loans growth is fixed effects (FE) model. A standard specification of a panel data model is:

$$Y_{it} = \beta_1 + \sum_{j=2}^{k} \beta_j X_{jit} + \sum_{p=1}^{s} \gamma_p Z_{pi} + \delta t + \varepsilon_{it} \tag{3.1}$$

where Y_{it} is the dependent variable with subscript *i* referring to each individual group or unit of observation (e.g., individual bank) and t referring to the time period, β_1 is a constant term, X_j are observed explanatory variables (there are k-1 of these variables indexed by a subscript *j*), Z_p are unobserved explanatory variables, t is a trend term that accounts for a potential shift of the intercept (constant term) over time. The error (disturbance) term ε_{it} is assumed to satisfy the usual linear regression assumptions, that is, having a normal distribution, not exhibiting autocorrelation, being uncorrelated with explanatory variables and lastly, being homoscedastic.

It is reasonable to assume that unobserved heterogeneity embedded in the model through variables Z_p is not changing over time, therefore these variables do not need a time index. Moreover, since they are unobserved, it is a common practice to treat them (i.e., an expression $\sum_{p=1}^{s} \gamma_p Z_{pi}$) as a single model component (Ibid., p. 517). Thus, the Equation 3.1 may be rewritten as:

$$Y_{it} = \beta_1 + \sum_{j=2}^{k} \beta_j X_{jit} + \mu_i + \delta t + \varepsilon_{it} \tag{3.2}$$

Where the unobserved heterogeneity (also known as the unobserved effect, or the individual-specific unobserved effect) is captured by:

$$\mu_i = \sum_{p=1}^{s} \gamma_p Z_{pi} \tag{3.3}$$

Further, if the unobserved effect (μ_i) is correlated with observed explanatory variables (X_j), then the regression estimates are subject to omitted variable bias and, more broadly, to the endogeneity problem. However, in this context, the omitted variable bias can be more precisely described as the heterogeneity bias (Bell & Jones, 2015, p. 138). Because of the omission of relevant individual-specific factors, the bias tends to inflate the magnitude of the covariates' coefficients in general when the unobserved effect is not eliminated from the regression model. In other words, even if the individual-specific unobserved effect is not correlated with any of the covariates, the presence of this effect will cause Ordinary Least Squares (OLS) estimates inefficient and OLS standard errors invalid (biased). The widely applied solution to this problem is to use fixed effects estimation, adopting for this purpose either the within-groups or the between approach. Both approaches are described and explained in the next section.

3.1.1 Within-groups and between fixed effects

In the within-groups approach, the specification presented in Equation 3.2 is transformed through the process of demeaning, that is subtracting the mean calculated across time periods from each term's and variable's initial values. This operation involves calculating mean values of the variables in the group of observations on a given individual (bank). Accordingly, the Equation 3.2 may be written as follows:

$$\bar{Y}_i = \beta_1 + \sum_{j=2}^{k} \beta_j \bar{X}_{ij} + \delta\bar{t} + \bar{\varepsilon}_i \tag{3.4}$$

Where, for example, the mean value of the dependent variable is equal:

$$\bar{Y}_i = \frac{\sum_{t=1}^{T} Y_{it}}{T_i} \tag{3.5}$$

In which T_i is the time length of each of group i (unit of observation), i.e., a number of time periods being non-missing observations on a given group. Afterward, the expression 3.4 can be subtracted from the Equation 3.2. This operation yields:

$$Y_{it} - \bar{Y}_i = \sum_{j=2}^{k} \beta_j \left(X_{jit} - \bar{X}_{ij}\right) + \delta(t - \bar{t}) + \varepsilon_{it} - \bar{\varepsilon}_i \tag{3.6}$$

As a result, in Equation 3.6 the unobserved effect (μ_i) is eliminated. The above specification 3.6 is the within-groups fixed effects regression model. It is worth noting that as a consequence of demeaning both a constant term and time-invariant explanatory variables disappear from this model. Nonetheless, the possibility of tackling and effectively eliminating the heterogeneity bias in the fixed-effects within-groups approach represents a major improvement for researchers in the field of panel data analysis.

The specification 3.4 is what is known as the between fixed-effects regression model. In the between approach, the unobserved term also drops out of the regression specification, thus allowing to avoid the omitted variable problem (i.e., heterogeneity bias). However, it is wort pointing out that this estimator uses only limited information from a given data set because it reduces the variation of variables to their means. Consequently, the between fixed-effects estimator allows researchers only to estimate and compare the variation between units of observation (e.g., between different banks) and does not capture the within-group (specific bank time-related) dynamics. The between fixed-effects estimator, like the within-groups estimator, provides estimates of time-varying factors exclusively[52].

3.1.2 Random effects and hybrid models

In the random effects (RE) model, the initial specification 3.2 is adjusted so that the disturbance term (ε_{it}) and the unobserved effect (μ_i) form together a composite error term ($\mu_i + \varepsilon_{it}$). Crucially, the unobserved heterogeneity is assumed to be a random variable, hence the name of the approach. Therefore, unobserved individual-specific factor μ_i (also called level 2 error or random intercept, see Schunck, 2013, p. 66) in the RE model is widely treated as a part of a conventional, random error term in the regression equation which is as follows:

$$Y_{it} = \beta_1 + \sum_{j=2}^{k} \beta_j X_{jit} + \delta t + \mu_i + \varepsilon_{it} = \beta_1 + \sum_{j=2}^{k} \beta_j X_{jit} + \delta t + v_{it} \tag{3.7}$$

Where the idiosyncratic level 1 error term ε_{it} is treated as a white noise and the composite random error term is equal to:

$$v_{it} = \mu_i + \varepsilon_{it} \tag{3.8}$$

Importantly, in order to obtain unbiased estimates of β_j coefficients, in the RE model (Equation 3.7) two conditions must be satisfied. Firstly, the unobserved variables must be randomly distributed. Specifically, the level 2 error and random intercept μ_i has to

[52] In assessing and comparing the goodness-of-fit measures, such as the R-squared, between the two described estimators, one should use the between R-squared for the former and the within R-squared for the latter.

come from a zero-mean normal distribution conditional on a given level of X_j, that is $\mu_i \mid X_j \sim N(0, \sigma_\mu^2)$. Secondly, the model provides consistent estimates if unobserved variables Z_p and therefore also μ_i are independently distributed from observed variables X_j, that is $Cov(\mu_i, X_j) = 0$.

As demonstrated in Schunck (2013) and Allison (2009), the random effects estimator turns out to be equivalent to estimation of a hybrid model (the so-called "within effects in random-effects models", see Schunck, 2013, p. 66) in which level 1 variables (i.e., variables that vary over time and between groups) are decomposed into a between ($\bar{X}_j$) and a within-groups or cluster component ($X_{jit} - \bar{X}_j$). The hybrid model is as follows:

$$Y_{it} = \beta_1 + \sum_{j=2}^{k} \beta_{2j}\left(X_{jit} - \bar{X}_j\right) + \sum_{j=2}^{k} \beta_{3j}\bar{X}_{ij} + \sum_{l=1}^{h} \beta_{4l}c_l + \delta t + \mu_i + \varepsilon_{it} \qquad (3.9)$$

The estimated coefficient β_2 provides a within-effect estimate, and hence is a fixed effects estimator, whereas the estimated coefficient β_3 gives a between estimate. Since specification 3.9 is a random effects model, it allows a researcher to include level 2 variables (denoted c_l above). The usual assumptions of RE model shown in Equation 3.7 have to hold also here. Under these assumption, estimation of the coefficient β_4 provides unbiased random-effect estimate of the parameters associated with variables that change only between groups (i.e., are constant within a group or cluster). As Schunck (2013) points out, the hybrid model shown in model 3.9 is closely related to the correlated random-effects model (see, Wooldridge, 2010), first proposed in the seminal work of Mundlak (1978).

Within effects embedded in random-effects models can also be formulated using the parametric approach. In particular, in the following regression model:

$$(Y_{it} - \theta\bar{Y}_i) = (1-\theta)\beta_1 + \sum_{j=2}^{k} \beta_j\left(X_{jit} - \theta\bar{X}_{ij}\right) + \{(1-\theta)\mu_i + (\varepsilon_{it} - \theta\bar{\varepsilon}_i)\} \qquad (3.10)$$

A parameter θ in Equation 3.10 is a function of σ_{μ}^{2} and σ_{ε}^{2}, that is a variance of the individual-specific random-intercept error (μ_i) and the conventional error term (ε_{it}), accordingly. If the former $\sigma_{\mu}^{2} = 0$, which means that the individual-specific error term is always zero, and $\theta = 0$, then specification 3.10 can be directly estimated by the OLS or the generalized least squares (GLS) method, that is a random effects model applies. Otherwise, in the other specific, extreme case, if the conventional (level 1) error term is equal to $\sigma_{\varepsilon}^{2} = 0$, that is ε_{it} is always zero, and $\theta = 1$, then the within effects estimator yields all the available information.

For more common (in-between) cases, in which none of variances are zero or $0 < \theta < 1$, fixed effects estimation requires fewer assumptions and hence is usually preferable, depending on the Durbin–Wu–Hausman (DWH) test results and other relevant statistics. Based on the DWH results, fixed effects (FE) or random effects (RE) estimator is applied according to the obtained result. The panel analysis can be further extended and regression specification presented in this Chapter can be modified in the case of encountering additional problems[53].

3.2 Data sources and variables

An empirical analysis of this study is based on the microeconomic bank institution-level data as well as macroeconomic aggregate data on economic and business cycle indicators. There are at least three advantages of using panel data, as indicated by Dougherty (2011).

Firstly, panel data sets are increasingly attractive for economic research because their use offers a solution to the omitted variable bias caused by unobserved individual-specific (to put precisely, bank-specific) effect. A second reason for the use of panel data sets is that they combine cross-sectional and longitudinal (time-series) dimensions, thus allowing a researcher to study both an influence of time dynamics and of individual (bank) specific characteristics on studied relationships. A third advantage of panel data

[53] For example, in order to mitigate the potential endogeneity problems in the present thesis a dynamic regression models are used, i.e., ones in which all bank-specific and macroeconomic control variables are lagged one period. It is a common practice applied in the empirical literature (cf. Kim & Sohn, 2017; Thornton & Tommaso, 2020). Furthermore, to deal with heteroscedastic and autocorrelated disturbance terms, standard robust variance-covariance estimators (VCE) are exploited, clustered at the individual-bank level.

sets is that they usually involve large datasets with a relatively large number of observations in comparison to traditional cross-sectional samples or time series data.

The main source of data used in the current study is Bank Orbis Focus database. It offers large and thorough bank-level financial datasets. The study uses annual observations on up to 3,494 active European banks spanning the period from 2011 to 2018 (inclusive). The panel of bank-years covers 54 European countries with the total of 27,952 observations. Such large sample size is mostly due to the extensive cross-sectional dimension of the dataset.

Bank-specific variables are derived from consolidated (5,944 observations that comprises 21.3% of the sample) and unconsolidated (22,008 observations comprising 78.7% of the sample) annual bank statements. These variables form the first data set described in detail in Table 3.1. Other sources of data collected for the research are multifold.

The main source of data on the ECB's quantitative easing, i.e., variables related to the Asset Purchase Program (henceforth APP) is the European Central Bank (ECB) and its Statistical Data Warehouse. These variables are part of the second data set shown in Table 3.1.

The country-specific and regulatory, i.e., micro and macro-prudential data for European countries come from various sources.

First, the source of variables and information on micro-prudential indicators and on the capital adequacy standards restrictiveness, such as "Overall Restrictions on Banking Activities", "Capital Regulatory Index" and "Official Supervisory Power", is a large financial dataset created by Barth, Caprio, and Levine (2013) (henceforth BCL). This database is based on the results of the survey IV conducted by BCL in 2011. It is worth emphasizing that the three micro-prudential indices have been transformed into 3-dimensional categorical variables in order to provide better use for interaction analysis.

The primary source of macroprudential regulations overall restrictiveness, and in particular of an international "Macroprudential Policy Index", is an extensive data set put together by Cerutti, Claessens, and Laeven (2015) (henceforth CCL). Data on market structure and development, such as "Bank Concentration" (based on bank assets) and the degree of government-owned banks in the banking system are derived from the BCL dataset “Market Structure Indicators” for 2011. The data on banking market concentration is consistent with “Global Financial Development Database” (GFDD) of the World Bank.

Euro area membership (henceforth EA) information is obtained from the European Commission (EC). Sample composition of euro area countries change over time to reflect the ongoing enlargement of the currency union. The Eurozone grew in the period 2011-2018 from seventeen countries (EA-17) to nineteen member states (EA-19). The above country-specific and regulatory variables make the third set of data presented in Table 3.1.

Data on macroeconomic and control variables are obtained from multiple sources. The source of the economic data on real gross domestic product (GDP) and inflation is the World Bank’s database “World Development Indicators” covering most of the countries in the sample. Data on the short-term rate of interest (3M money market rates) is the OECD’s Financial data set. Eurostat is a source for data on long-term interest rate; and the Centre for Economic Policy Research (CEPR) is a source of the data on periods of recessions in the euro area. The macroeconomic and control variables form together the fourth set of data described in detail in Table 3.1. below.

Table 3.1. Description, definition and sources of all variables used in the empirical research

	Name of variable	**Definition and/or transformation**	**Name in models**	**Data source**
Set I	**Bank-specific variables**			
1.	Net loans[54]	Total gross loans less reserves for impaired (non-performing) loans	loans	Bank Orbis Focus
2.	Net loans (relative to total assets)	100 × net loans/ total assets	loans_rel	
3.	Net loans (logarithm)	ln (loans_t)	Lloans	
4.	Net loans (logarithm of relative value)	ln (loans_t/ total assets_t)	Lloans_rel	
5.	Net loans (growth of logarithm)	100 × [ln (loans_t) - ln (loans_t-1)]	DLloans	

[54] All bank-specific variables (balance sheet items) obtained from Bank Orbis Focus database are in EUR thousands except for calculated ratios, relative values and categorical variables.

6.	Net loans growth rate	100 × (loans_t - loans_t-1) / loans_t-1	dloans	
7.	Equity capital ratio	Total equity / total assets	ECR	
8.	Tier 1 ratio	Tier 1 capital / total risk-weighted assets	Tier1ratio	
9.	Total capital ratio	Total capital / total risk-weighted assets	TCR	
10.	Total assets (logarithm)	ln (total assets)	Lsize	
11.	Total customer deposits (relative to total assets)	100 × total customer deposits/ total assets	Deposits_rel	
12.	Loans to deposits ratio	Net loans / total customer deposits	LTD	
13.	Market funding	100 × non-deposit liabilities / total assets	MFUND	
14.	Profit before tax (relative to total assets)	100 × profit before tax / total assets	PBT_rel	
15.	Return on equity	100 × net income / total equity	ROE	
16.	Return on assets	100 × net income / total assets	ROA	
17.	Liquid assets[55] to short-term funding ratio	Liquid assets / (total customer deposits + short-term funding)	LADSTF	
18.	Liquid assets to deposits and borrowing ratio	Liquid assets / (total deposits + borrowing)	LATDB	
19.	Interbank market funding ratio	Interbank liquidity “due from banks” / “due to banks”	IBF	
20.	Cash and balances at central bank	100 × cash and balances at central bank / total assets	CBCB_rel	
21.	Loan loss provisions (LLPs) to total gross loans	100 × loan loss provisions / total gross loans	Provisions	
22.	Impaired loans (non-performing loans, NPLs) to total gross loans	100 × non-performing loans / total gross loans	NPL	

55 A category of “Liquid assets” in Bank Orbis Focus database include: “the sum of ‘Cash and Due from Banks’, ‘Deposits with Banks’, ‘Due from Central Banks’, ‘Due from Other Banks’, ‘Due from Other Credit Institutions’, ‘Treasury Bills’, ‘Other Bills’, ‘Government Securities’, ‘Trading Securities’, ‘CDs’” (Bunda & Desquilbet, 2009, p. 31).

23.	Bank size category	It is a categorical variable based on the empirical distribution of bank-level time averages of the total assets. Values of average total assets less than the 1st quartile are recoded as 1 (“small banks”) – 25 % of the sample; values that lie in between the 1st and 3rd quartiles (inclusive) are recoded as 2 (“medium-sized banks”) – 50% of the sample; and values larger than the 3rd quartile are recoded as 3 (“large banks”) – 25% of the sample.	Size_category [k] where k = 1, …, 3	
24.	Capital category	It is a categorical variable based on the empirical distribution of bank-level time averages of the equity capital ratio (ECR) in the period 2011-2013. Poorly capitalized (“low-capital” – category 1) banks are banks whose average ECR was less than 8% in the period 2011-2013. “Medium-capital” (category 2) banks are banks whose average ECR in the same period was between 8% (inclusive) and 10%. Highly capitalized (“high-capital” – category 3) banks are banks whose average equity capital ratio (ECR) in the 2011-2013 period was greater than or equal to 10%.	Capital [k] where k = 1, …, 3	
25.	Liquidity category	It is a categorical variable based on the empirical distribution of bank-level time averages of the loans to deposits ratio (LTD). “High-liquidity” (category 1) banks are banks whose average LTD is less than 80% in the full sample period. “Medium-liquidity” (category 2) banks are banks whose average ECR in the	Liquidity [k] where k = 1, …, 3	

		full sample period is between 80% (inclusive) and 120%. Banks with low level of liquidity (category 3: “low-liquidity” banks) are banks whose average LTD in the 2011-2018 period was greater than or equal to 120%.		
26.	Bank specialization category	It is a categorical variable that is equal to: 1 for a “Commercial bank”; 2 for a “Cooperative bank”; and 3 for a “Savings bank”.	Specialization [k] where k = 1, …, 3	
Set II	**ECB’s quantitative easing variables**			
1.	Asset Purchase Program (APP; total value; flow variable)	Sum of all four APP programs (annual net purchases) for all countries of risk in each year	APP	European Central Bank and its Statistical Data Warehouse
2.	Asset Purchase Program (binary variable)	Dummy for all four APP programs, 1 - for countries of risk (i.e., issuer’s country) in years when at least one program was being actively implemented; 0 – otherwise.	APP_d	
3.	Asset Purchase Program (relative to total assets)	Total value of APP purchases/ bank's total assets	APP_rel	
4.	Public Sector Purchase Program (PSPP; flow variable)	Annual net purchases under the PSPP (flow), breakdown by country of risk (i.e., issuer’s country). Book value in EUR thousands. Reported net of redemptions.	PSPP	
5.	Public Sector Purchase Program (binary variable)	In years and countries when PSPP purchases were actively made the variable equals 1, otherwise equals 0.	PSPP _d	
6.	Asset-Backed Securities Purchase Program (ABSPP; stock variable)	Year’s end holding of asset-backed securities (ABS) at amortized cost (stock), breakdown by country of risk distribution at the end of Q3 2019. Book value in EUR thousands. Reported net of redemptions.	ABSPP_c	
7.	Asset-Backed Securities Purchase	In years and countries when ABSPP purchases were actively made the variable equals 1, otherwise equals 0.	ABSPP _d	

	Program (binary variable)			
8.	Asset-Backed Securities Purchase Program (continuous flow variable)	Annual net purchases under the ABSPP (flow), breakdown by country of risk distribution at the end of Q3 2019. Book value in EUR thousands. Reported net of redemptions.	ABSPP _f	
9.	third Covered Bond Purchase Program (CBPP3; stock variable)	Year's end holding of covered bonds at amortized cost (stock), breakdown by country of risk distribution at the end of Q3 2019. Book value in EUR thousands. Reported net of redemptions.	CBPP3_c	
10.	third Covered Bond Purchase Program (binary variable)	In years and countries when CBPP3 purchases were actively made the variable equals 1, otherwise equals 0.	CBPP3_d	
11.	third Covered Bond Purchase Program (flow variable)	Annual net purchases under the CBPP3 (flow), breakdown by country of risk distribution at the end of Q3 2019. Book value in EUR thousands. Reported net of redemptions.	CBPP3_f	
12.	Corporate Sector Purchase Program (CSPP; stock variable)	Year's end holding of corporate sector securities at amortized cost (stock), breakdown by country of risk distribution at the end of Q3 2019. Book value in EUR thousands. Reported net of redemptions.	CSPP_c	
13.	Corporate Sector Purchase Program (CSPP; binary variable)	In years and countries when CSPP purchases were actively made the variable equals 1, otherwise equals 0.	CSPP_d	
14.	Corporate Sector Purchase Program (CSPP; flow variable)	Annual net purchases under the CSPP (flow), breakdown by country of risk distribution at the end of Q3 2019. Book value in EUR thousands. Reported net of redemptions.	CSPP_f	
Set III	**Country-specific and regulatory variables**			
1.	Restrictions on Banking Activities	Overall Restrictions on Banking Activities; integer ranging from 3 to 12. Higher	Act_restrict	Barth, Caprio, and Levine (BCL) 2013

		values indicate more strictive. It is transformed into a categorical variable based on the empirical distribution of its bank-level time averages. Values of Act_restrict less than its 33th percentile are recoded as 1 ("low restrictiveness" category), between 33th (inclusive) and 67th percentiles are recoded as 2 ("medium restrictiveness" category) and values more than or equal to 67th percentile are recoded as 3 ("high restrictiveness" category).		Micro-prudential Dataset; data from Survey IV for 2011
2.	Capital Regulatory Index	Capital Regulatory Index; integer ranging from 0 to 10. Higher values indicate greater stringency. It is transformed into a categorical variable based on the empirical distribution of its bank-level time averages. Values of Cap_reg less than its 33th percentile are recoded as 1 ("small stringency" category), between 33th (inclusive) and 67th percentiles are recoded as 2 ("medium stringency" category) and values more than or equal to 67th percentile are recoded as 3 ("large stringency" category).	Cap_reg Cap_reg[k] where k = 1, …, 3	
3.	Official Supervisory Power	Official Supervisory Power; integer ranging from 0 to 14. Higher values indicate greater power. It is transformed into a categorical variable based on the empirical distribution of its bank-level time averages. Values of Sup_power less than its 33th percentile are recoded as 1 ("small power" category), between 33th	Sup_power Sup_power[k] where k = 1, …, 3	

		(inclusive) and 67th percentiles are recoded as 2 (“medium power” category) and values more than or equal to 67th percentile are recoded as 3 (“large power” category).		
4.	Bank Concentration (assets based)	The degree of concentration of assets in the 5 largest banks (in percent). Percentage of banking system’s total assets that are held by the five largest banks. It is transformed into a categorical variable based on the empirical distribution of its bank-level time averages. Values of Bank_conc less than its 33th percentile are recoded as 1 (“small degree of concentration” category), between 33th (inclusive) and 67th percentiles are recoded as 2 (“medium degree of concentration” category) and values more than or equal to 67th percentile are recoded as 3 (“large degree of concentration” category).	Bank_conc Bank_conc[k] where k = 1, …, 3	Market Structure Indicators (data for 2011)
5.	Government-Owned Banks	Percentage of banking system's assets in banks that are 50% or more government owned. It is transformed into a categorical variable based on the empirical distribution of its bank-level time averages. Values of Gov_banks less than its 33th percentile are recoded as 1 (“low degree of state-owned banks” category), between 33th (inclusive) and 67th percentiles are recoded as 2 (“medium degree of state-owned banks” category) and values more than or equal to 67th percentile are recoded as 3 (“high degree of state-owned banks” category).	Gov_banks Gov_banks[k] where k = 1, …, 3	

6.	Macroprudential Index (MPI)	MPI measures overall macroprudential policy restrictions. Integer ranging from 0 to 12. Higher values indicate more restrictive macroprudential policy. Data for years between 2011-2017.	MPI	Cerutti, Claessens, and Laeven (CCL) 2017 Macroprudential Dataset
7.	Euro area membership (binary variable)	Binary variable that indicates EMU Member States that adopted the euro as a single currency, and therefore form the euro area (in the 2011-2018 period[56]).	EA	European Commission
Set IV[57]	**Macroeconomic and control variables**			
1.	Real GDP growth	Annual growth rate of Gross Domestic Product constant 2010 prices	GDP_growth	World Bank (World Development Indicators)
2.	Real GDP (logarithm)	ln (GDP constant 2010 prices)	LGDP_real	
3.	CPI inflation rate	Annual rate of inflation as measured by Consumer Price Index	CPI	
4.	Short-term interest rate	3M money market rates (annualized)	INT_ST	OECD (Financial data)
5.	Long-term interest rate	EMU convergence criterion 10-year government bond yields	INT_LT	Eurostat
6.	Recession in the euro area (binary variable)	Binary variable that indicates years in which a recession period occurred in the euro area (i.e., sovereign debt crisis). It lasted from 2011Q3 to 2013Q1, as declared by the CEPR Euro Area Business Cycle Dating Committee[58]. Annualization	Recession	Centre for Economic Policy Research

[56] Sample composition of euro area countries change over time to reflect the ongoing enlargement of the currency union. The Eurozone grew in the sample period from seventeen countries (EA-17) in 2011 to nineteen countries (EA-19) in 2018. See: https://ec.europa.eu/info/business-economy-euro/euro-area/what-euro-area_en

[57] Summary statistics of four distinct sets of variables along with their respective data coverage in the sample are presented in Table 3.2. in Section 3.3.

[58] According to the Centre for Economic Policy Research (CEPR) definition for the entire euro area (EA-19). In October 2015, the Euro Area Business Cycle Dating Committee publicly announced that “the trough of the recession that started after the 2011Q3 peak has been reached in 2013Q1. The trough signals the end of the second recession witnessed by the euro area after the financial crisis. The recession lasted six

		based on at least one recessionary quarter for a year implies that the dummy equals one for years from 2011 to 2013 and zero otherwise.		

Source: own elaboration.

3.3 Initial data treatment

Data management is a very important aspect of panel data analysis. Especially, in the case of a sample of banks characterized by large diversity and heterogeneity, which is the condition of the present empirical study. The procedure of initial data treatment involves several stages.

First, I divide the full sample into subsamples by three crucial criteria for two reasons. In the first place, such procedure allows me to verify empirical hypotheses even for the factors and variables that not change over time and therefore could not be estimated by the fixed effects estimator. Secondly, such method is justified in the view of the literature described and critically assessed in Chapter 1. Bank-specific characteristics such as bank size or bank liquidity turn out to play a large role in explaining the relationship between bank loans growth and capital ratios.

Employing the approach similar to Olszak, Pipień, Roszkowska, & Kowalska (2018), first, based on the bank size criterion three groups are formed: large banks – the upper quarter (25%) of the sample in terms of the total asset size, then 50% banks (two middle quarters of the distribution) in the sample are considered medium-sized, and lastly banks in the bottom 25% of the sample are consider small. This operation is described in detail in Table 3.1. under the name of Bank size category.

Based on the bank equity capital (ECR) ratio, banks are considered highly capitalized if their equity capital ratio is equal or exceeds 10%. Otherwise, they are categorized as medium capitalized if the ratio is below 10% but higher or equal to 8%. Finally, banks are considered poorly capitalized if the ECR ratio is below 8%. The reason for such categorization is that, although the total capital adequacy ratio (i.e., the tier 1 plus tier 2 capital) is regulatory binding at the minimum of 8%, the two percentage points

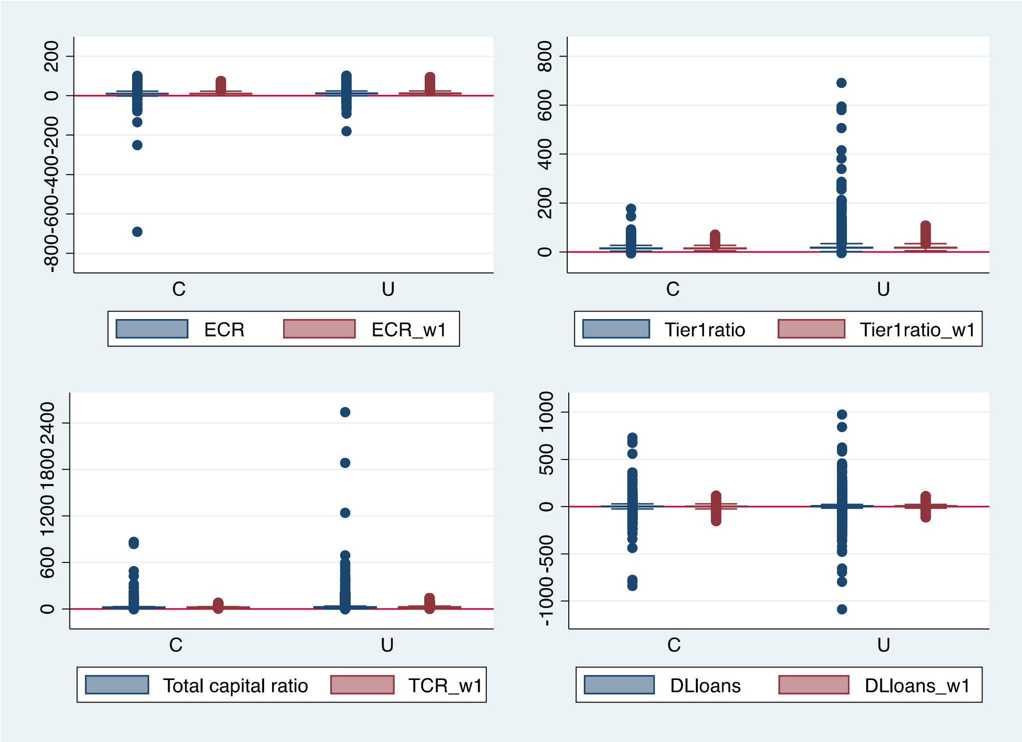
quarters; the 2011Q3-peak to 2013Q1-trough cumulative decline in output has been a mild 1.5 percent." See: https://cepr.org/content/euro-area-business-cycle-dating-committee-announcements of an additional ‘buffer’ seems reasonable and prudent to classify them as ‘well-capitalized’ (Olszak et al., 2016, p. 13). Thus, if the ECR < 8% banks are classified as ‘low cap’, if ECR ≥ 8% and ECR < 10% ‘medium cap’; and if ECR ≥ 10% ‘high cap’. This operation is described in detail in Table 3.1. under the name of Capital category.

The third categorization is based on the loan-to-deposit (LTD) ratio. The ratio constitutes a clear and straightforward indicator of the bank overall liquidity situation, indicating specifically the size of liquidity mismatch risk (Van den End, 2016, p. 237). As Van den End (2016) points out, LTD ratio values exceeding 120% or being lower than 80% are associated accordingly either with a potential banking crisis or with impaired financial intermediation. Both the ECB and the IMF apply similar standards with regard to reference points for the LTD ratio, i.e. lower bound being 80% and upper bound being equal to 120% (Van den End, 2016, p. 248). In line with this approach, the following critical thresholds are used. Banks are classified as ‘medium liquid’ if their LTD is equal or higher than 80% but lower than 120%; ‘highly liquid’ if their LTD is below 80%; and as ‘low liquid’ if their LTD is larger than or equal to 120%. This operation is described in detail in Table 3.1. under the name of Liquidity category.

The second stage of initial data treatment involves management of data outliers. Relatively high prevalence of extreme observations in the sample both of consolidated and unconsolidated data can be visually detected in Figure 3.1. In order to mitigate the negative effects of outliers (that occur in the sample due to misreporting or other data collection errors), all bank-specific variables except for bank size (the variable *Lsize*) are winsorized. Following the approach of Kim and Sohn (2017), extreme bank-specific observations are winsorized at the 1st and 99th percentiles in the sixteen subsamples grouped by the consolidation type (two types of data: consolidated and unconsolidated) and year (eight periods)[59]. As Figure 3.1. shows this method allows for removing extreme values both from consolidated and unconsolidated samples[60].

[59] Note that applying the winsorization as initial data treatment method means that values smaller than the 1th percentile are replaced by the 1th percentile, and the analogous operation is performed at the 99th percentile. Thus, as a result of this treatment the number of observations does not change but the dataset becomes less skewed.
[60] In Section 4.4 of the thesis it is checked if the main results of the study are robust to changing the standard winsorization level (using alternatively the 0.5th and 99.5th percentiles or the 2nd and 98th percentiles).

Figure 3.1. Outliers in box-and-whisker plots of key variables grouped by consolidation type



Notes: "C" denotes consolidated and "U" unconsolidated data. A suffix "w1" indicates that a variable is winsorized at the 1st and 99th percentiles. The graphs are created based on the full sample.
Source: own elaboration.

In the third stage, observations that are likely to involve bank mergers and acquisitions taking place in the European banking sector are controlled for in the estimation sample by applying two methods. Firstly, based on the history of individual banks – information obtained from the Bank Orbis Focus database as a qualitative variable that describes a "History (for banks)" – both mergers and acquisitions (and absorptions) that occurred in the sample period are effectively excluded from estimations. Secondly, in order to further increase the likelihood that all M&As are controlled, observations that involve greater than 50% or less than −50% annual growth in total assets are also excluded from the sample. The same procedure of controlling for abnormal growth in assets has been applied in the study of Kim & Sohn (2017, p. 98).Together the two operations of the third stage of the initial data treatment reduce the size of unconsolidated data sample considerably from 22,008 observations to 11,597 observations on active banks. The sample consisting of unconsolidated data is analogously reduced from 5,944 to 2,865 observations.

The regression analysis is performed on an adjusted unconsolidated sample (N = 11,597), that is, on the sample after controlling for outliers (with data winsorization) and after taking account of observations that involve mergers and acquisitions or abnormal growth. Summary statistics of variables presented in Table 3.2. are calculated on the adjusted (final) sample. In addition, all correlation matrices and tables, including both Pearson's and Spearman's correlation coefficients, that are presented in Annex from Table A.1. to Table A.12. are also based on this sample.

Table 3.2. Summary and descriptive statistics of four distinct sets of variables

	Bank-specific variables					
Set I	**N**	**Mean**	**Median**	**Std. Dev.**	**Min**	**Max**
loans_rel	11,446	57.26	59.58	19.14	0.58	94.87
DLloans	11,417	2.16	3.53	18.72	-111.14	108.90
dloans	11,419	3.92	3.59	19.94	-70.91	197.12
ECR	11,564	14.04	10.58	12.51	1.29	93.65
Tier1ratio	6,753	21.03	17.00	13.70	4.87	107.18
TCR	8,015	23.83	18.90	16.21	3.70	140.21
Lsize	11,597	12.60	12.48	1.59	7.08	19.43
Deposits_rel	11,304	70.68	76.09	18.74	0.46	93.00
LTD	11,258	1.09	0.80	2.12	0.02	27.65
MFUND	11,275	15.74	10.77	16.05	0.31	86.39
PBT_rel	11,558	0.67	0.55	1.57	-10.97	8.40
ROE	11,522	3.67	3.53	8.48	-56.45	36.68
ROA	11,553	0.47	0.38	1.39	-10.54	7.25
LADSTF	11,389	30.45	21.08	33.06	1.11	288.06
LATDB	7,914	26.24	17.57	27.45	0.71	222.41
IBF	7,860	178.04	83.34	218.73	1.17	956.69
CBCB_rel	11,325	5.29	1.42	9.72	0.00	61.12
Provisions	11,031	0.67	0.18	2.34	-8.97	20.38
NPL	7,878	8.39	3.84	12.49	0.01	93.23
	ECB's quantitative easing variables					
Set II	**N**	**Mean**	**Median**	**Std. Dev.**	**Min**	**Max**
APP	11,597	4.32E+07	6.51E+6	6.72E+07	0.00	2.16E+08
APP_rel	11,597	166.71	9.24	787.70	0.00	48312.60
APP_d	11,597	0.58	1.00	0.49	0.00	1.00
PSPP	11,597	3.60E+07	0.00	5.74E+07	-37000.00	1.88E+08
PSPP_d	11,597	0.48	0.00	0.50	0.00	1.00
ABSPP_c	11,597	8.42E+05	0.00	1.35E+06	0.00	1.46E+07

ABSPP_f	11,597	3.52E+05	0.00	6.74E+05	0.00	5.57E+06
ABSPP_d	11,597	0.44	0.00	0.50	0.00	1.00
CBPP3_c	11,597	1.38E+07	3.26E+06	1.73E+07	0.00	7.08E+07
CBPP3_f	11,597	4.02E+06	6.45E+05	6.51E+06	0.00	3.07E+07
CBPP3_d	11,597	0.53	1.00	0.50	0.00	1.00
CSPP_c	11,597	5.66E+06	0.00	1.25E+07	0.00	5.34E+07
CSPP _f	11,597	2.79E+06	0.00	5.75E+06	0.00	2.42E+07
CSPP _d	11,597	0.23	0.00	0.42	0.00	1.00
	Country-specific and regulatory variables					
Set III	**N**	**Mean**	**Median**	**Std. Dev.**	**Min**	**Max**
Act_restrict	8,353	5.64	5.00	1.77	3.00	11.00
Cap_reg	10,963	6.47	7.00	1.74	3.00	10.00
Sup_power	10,260	10.98	11.00	1.77	7.00	14.00
Bank_conc	11,103	49.01	47.70	21.01	24.93	100.00
Gov_banks	11,065	18.50	16.10	15.08	0.00	71.70
MPI	11,492	3.63	4.00	1.21	0.00	8.00
	Macroeconomic and control variables					
Set IV	**N**	**Mean**	**Median**	**Std. Dev.**	**Min**	**Max**
GDP_growth	11,478	1.60	1.74	1.71	-9.77	25.16
LGDP_real	11,478	20.39	20.95	1.34	14.08	21.81
CPI	11,376	2.36	1.51	4.41	-1.74	59.22
INT_ST	10,824	1.22	-0.02	3.42	-0.78	14.76
INT_LT	10,879	2.31	1.42	2.74	-0.36	22.50
Recession	11,597	0.12	0.00	0.32	0.00	1.00

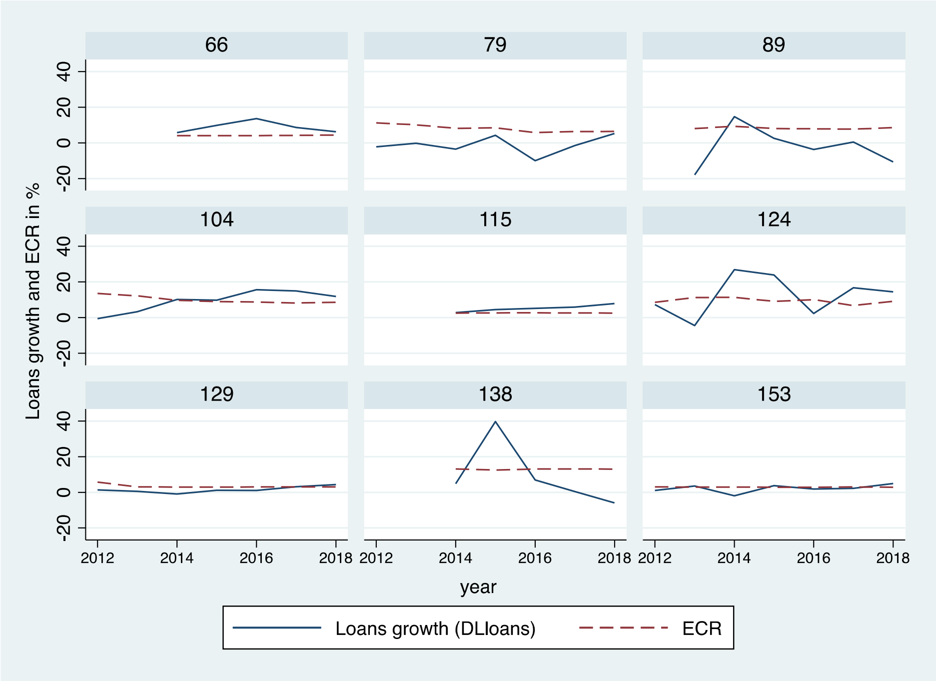
Notes: N indicates number of observations. Maximum number of observations in the panel is N = 11,597. Presented variables are restricted to and based on unconsolidated data from annual bank statements. All bank-specific variables are winsorized at the 1st and 99th percentiles, except for the size variable *Lsize* which is a logarithm of total assets. Potential mergers and acquisitions are excluded based on the Orbis qualitative variable that describes a history (for banks). Observations involving greater than 50% or less than −50% annual growth in total assets are excluded from the sample to further reduce a possibility of M&As.
Source: own elaboration.

3.4 Preliminary data analysis

As a first step of preliminary data analysis, graphs of key regression variables are presented, that is of bank loans growth and of three key capital ratios, in order to investigate how they develop over time. The series are plotted in the panel-data line graphs for a non-random sample of banks based on the final (outliers and M&A-adjusted)

sample of unconsolidated data. For example, Figure 3.2. depicts the equity capital ratio (ECR) expressed in percent and the annual growth rate of bank net loans.

Figure 3.2. Growth rate of bank loans and the equity capital ratio (ECR)



Notes: The number above of each plot indicates the identifying number of a specific bank, i.e., the bank id number. Graphs are created based on the final sample of unconsolidated data.
Source: own elaboration.

The above figure shows that while the ECR capital ratio seems to fluctuates only to a limited extent, for many banks the loans growth varies considerably over time.

Figure 3.3., which presents overlaying dynamics for the same subsamples of banks, provides further evidence for this phenomenon. In addition, this graph points to the evidence of constant or slightly declining capital ratios in the 2012-2018 period and to a contemporaneous increase in the bank lending in 2015 and a marked decrease in bank loans growth in years 2014 and 2016 (see Figure 3.3.).

Figure 3.3. Growth rate of bank loans and the equity capital ratio (ECR) in the overlaid plot

Notes: The graphs are created based on the final sample of unconsolidated data.
Source: own elaboration.

In order to reveal further dynamics in the key regression variables an investigation into their average and median values is reported in Table 3.3. It provides the summary statistics describing the mean and median of the bank loans growth, three capital ratios and the real GDP growth in each year.

Table 3.3. Summary statistics of bank loans growth, capital ratios and the real GDP growth

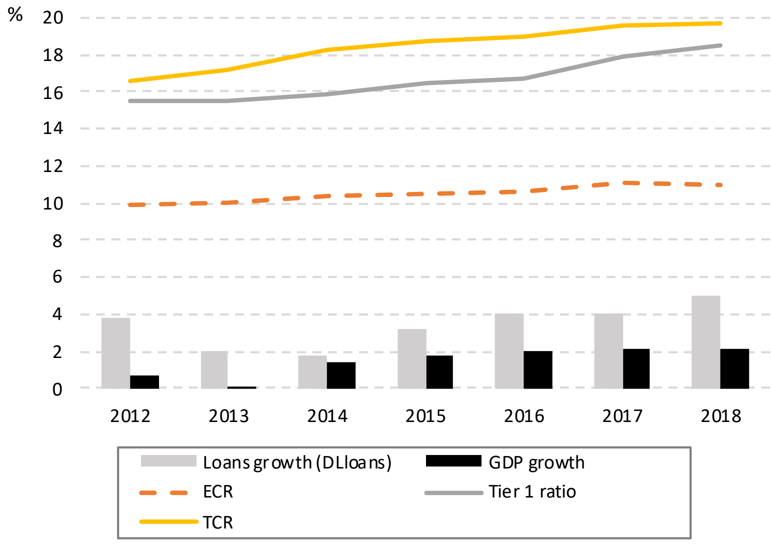
		Dynamics of bank-specific and macroeconomic variables						
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Loans growth (DLloans)	Mean	5.36	2.33	-2.77	-0.05	3.71	2.58	5.10
	Median	3.85	2.07	1.81	3.21	4.03	4.01	5.06
	Std. Dev.	11.38	10.13	21.58	18.81	17.96	17.67	20.67
	N	642	712	1,741	1,881	1,995	2,222	2,224
ECR	Mean	11.18	11.46	13.95	14.10	14.22	14.82	14.78
	Median	9.92	10.03	10.36	10.49	10.57	11.05	10.92
	Std. Dev.	6.35	7.88	12.55	12.41	12.78	13.10	13.96
	N	645	716	1,763	1,904	2,021	2,260	2,255
Tier 1 ratio	Mean	17.68	17.57	18.09	19.06	19.73	23.24	24.97

	Median	15.50	15.51	15.84	16.47	16.68	17.85	18.50
	Std. Dev.	9.19	8.65	9.55	10.93	10.93	15.70	17.85
	N	223	286	1,051	1,158	1,215	1,400	1,420
TCR	Mean	18.77	19.13	21.59	22.55	23.05	25.71	27.21
	Median	16.57	17.13	18.24	18.68	18.98	19.57	19.70
	Std. Dev.	8.65	9.59	13.00	14.50	14.26	17.58	20.53
	N	276	344	1,259	1,374	1,448	1,658	1,656
GDP growth	Mean	-0.28	-0.09	1.29	1.07	1.92	2,47	2.18
	Median	0.68	0.03	1.38	1.74	2.04	2.16	2.14
	Std. Dev.	1.61	1.30	1.52	2.49	0.96	1.03	1.14
	N	637	705	1,748	1,891	2,006	2,246	2,245

Notes: This table is based on the final sample of unconsolidated data. Maximum number of observations in the panel is N = 11,597.
Source: own elaboration.

An initial hypothesis of declining bank capital ratios in 2012-2018 is not supported by median values of these capital indicators, as illustrated in Figure 3.4. On the other hand, a drop in the growth rate of real GDP in 2013 and a concurrent decline in the bank lending in years 2013-2014 are pronounced and clearly visible. Figure 3.4. and Table 3.3. confirm that both average and median values of the equity capital ratio (ECR – represented by an orange dashed line in Figure 3.4.), total capital ratio (TCR) and tier 1 ratio have been rising in the period of 2012-2018. The median ECR has risen from 9.92% in 2012 to 10.92% in 2018, that is, precisely by one percentage point, while at the same time the median tier 1 ratio and TCR have grown from 15.50% and 16.57% to 18.50% and 19.70%, respectively, i.e., by roughly three percentage points (see Figure 3.4.). The growth of key bank capital ratios most likely reflects the process of bank balance sheets strengthening (i.a., in the form of deleveraging) and bank recapitalization in Europe during the sovereign debt crisis and after the ensuing economic recession of 2011-2013.

Figure 3.4. Median values of bank loans growth rate, capital ratios and the real GDP growth

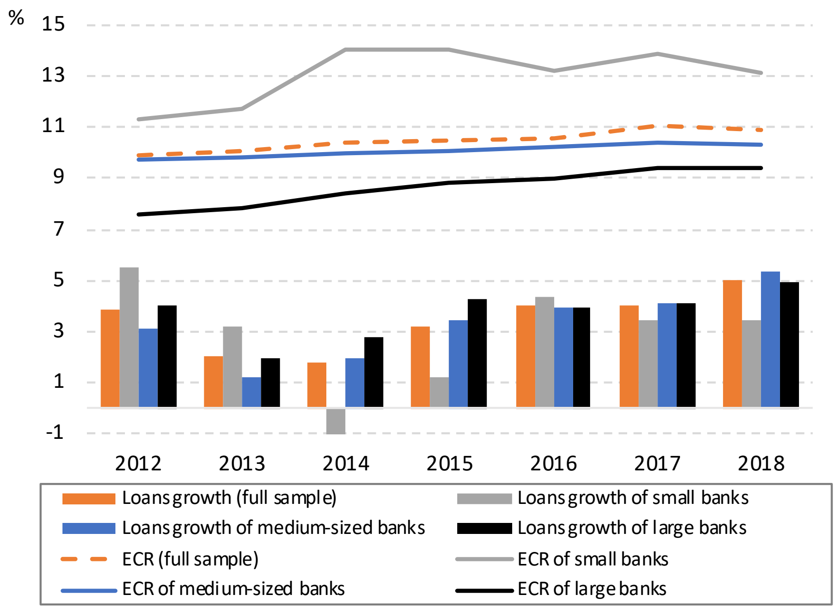


Notes: The graph is based on the final sample of unconsolidated data.
Source: own elaboration.

Figure 3.5. provides more detailed view on dynamics of bank loans growth and the equity capital ratio when banks are classified into three groups based on their assets size. The figure supports the view of banks' heterogeneity with regard to their size. This diversity refers not only to the level of equity capital (to total assets) that they hold but also to the trajectory of loans and credit they supply.

Loans supplied by small banks exhibited on average a higher volatility in comparison to large and medium-sized banks. Loans of small banks (the bottom 25% with regard to total assets – represented by gray line and bars in Figure 3.5.) of banks were growing faster than the average (represented by orange bars) during the recession, i.e. in the 2012-2013 period. The median growth rate of small banks' lending gradually dropped into negative territory in 2014. Loans supplied by large banking firms were the most robust to economic downturns in the whole studied period; he median value of their annual loans growth never declined below 1.0%. On the other hand, lending of medium-sized banks reflects the dynamics of the full sample, not unexpectedly as these banks constitute exactly half of the final sample. The median growth rates of banks of different size have eventually harmonized in the three-year period between 2016 and 2018 (with median growth of lending oscillating between 3.0% and 5.5%).

Figure 3.5. Median values of ECR and bank loans growth in full sample and for small, medium-sized and large banks



Notes: The graph is created based on the final (adjusted) sample of unconsolidated data. A "full sample" includes banks of all size.
Source: own elaboration.

Median equity capital ratio of small banks was significantly higher than the average and large banks. A median small bank held on average 4.39 percentage points higher equity capital ratio than a median large bank in the 2012-2018 period. Namely, the ECR of small banks was 13.04% and of large banks was 8.65% on average. While in the same period, the growth rate of loans extended by large banks outperformed the growth rate of small banks' loans by 0.85 percentage point, on average (growth rate of 3.74% of large banks and 2.89% of small banks). The ECR of medium-size banks, as expected, followed an upward trend of a median bank in full sample (represented by an orange dashed line in Figure 3.5.). The ECR of these banking firms being equal to 10.08% on average (and 10.48% for a median bank in the full sample). Similarly, the annual growth rate of loans extended by medium-sized banks reflected the full sample median as in the case of the former it was equal to 3.31% compared to loans growth of 3.43% in the case of a median bank in the full sample.

Chapter 4. Research results

4.1 Baseline model

In this section, the regression analysis using the robust fixed effects estimator is employed to identify the determinants of the impact of quantitative easing policy of the ECB on the link between bank loans growth and capital ratios in Europe. The baseline model and the interactive models are accordingly estimated to achieve this objective. The two specification are then checked with a use of the Hausman (DWH) test in order to determine whether the fixed effect regression model is in fact preferable in the context of the present empirical study.

Panel data econometric models will be a tool for testing and verifying the validity of the following five research questions posed in Chapter 1 of the present thesis:

Q1: *Was the relationship between bank capital ratios and bank loans growth for European banks in the 2011-2018 period non-linear?*

Q2: *Was the sign in the relationship between bank capital ratios and bank loans growth for European banks in the 2011-2018 period in general positive?*

Q3: *Did the relationship between bank capital ratios and bank lending growth depend on a bank's size and specialization in the 2011-2018 period for European banks?*

Q4: *Did the relationship between bank capital ratios and bank lending growth depend on the bank's initial level of capitalization (that is, the initial capital-to-asset ratio) in the 2011-2018 period for European banks?*

Q5: *Did the relationship between bank capital ratios and bank lending depend on the bank's relative liquidity position expressed in its liquidity ratios in the 2011-2018 period for European banks?*

Estimated models and obtained estimates of their coefficients will allow me to test and verify five empirical hypotheses already put forward in Chapter 2 of the present thesis. The empirical hypotheses which stem from the reviewed and relevant literature are as follows:

H1: *the effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB*

H2: *the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for large banks with sufficient level of liquidity*

H3: *the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for well-capitalized banks with sufficient level of liquidity*

H4: *the effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB only for banks from countries characterized by more restrictive capital regulations and more stringent overall restrictions on banking activities*

H5: *the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for banks from countries characterized by more concentrated structure of the banking sector and higher share of state-owned banks*

The regression specification is designed to investigate the sign in the relationship between bank loans growth on the one hand, and bank capital ratios on the other. In the baseline model, similar to the one proposed in Brei, Gambacorta, & von Peter (2013) and Kim & Sohn (2017), bank loans growth ($L_{i,t}$) is the dependent (endogenous) variable and a bank capital ratio ($CAP_{i,t}$) is the main regressor of interest. In the baseline model and first interactive models, I compare the results obtained for two alternative measures of bank loans growth, that is, the net loans growth of logarithm and the net loans growth rate, denoted in Table 3.1. as *DLloans* and *dloans*, respectively.

In the study, I exploit three different measures of the capital position. First, the equity capital ratio ($ECR_{i,t}$) is used because it has an advantage of the highest data coverage in the final – adjusted for outliers and M&As – sample (see all descriptive statistics in Table 3.2.). Second, I also use two regulatory bank capital adequacy ratios, which are officially binding for most of banks in the sample, that is the Tier 1 capital ratio ($Tier1_{i,t}$) and the Total capital ratio ($TCR_{i,t}$). The former being a ratio of Tier 1 capital to bank risk-weighted assets (RWAs). The latter is a sum of regulatory Tier 1 and Tier 2 capitals expressed as a percentage of RWAs.

A proxy of the liquidity ratio (LIQ_{t-1}), which is included in all empirical specifications, is the ratio of liquid assets to short-term funding and customer deposits (*LADSTF*). This liquidity ratio has the highest data coverage and quality compared to other bank liquidity proxies (see Table 3.2. for details). As a robustness check exercise, *LADSTF* is replaced with the liquid assets to deposits and borrowing ratio (*LATDB*) in the interactive model in Section 4.3.

The conventional monetary policy and general economic conditions effects are captured by adding one-period lagged changes in official policy interest rates (ΔINT_ST_{t-1}) and in the growth of the real GDP (ΔGDP_{t-1}). The macroprudential policy is controlled for by the Macroprudential Policy Index (MPI_{t-1}) – an updated index developed by Cerutti et al. (2015) – which measures the overall restrictiveness of macroprudential policy in every country. Demand-side factors in the market for bank loans are proxied by changes in the overall economic activity and periods of downturns in the business cycle, namely by the real GDP growth and the euro-area recession dummy (R_t). An annual change in the consumer prices level (CPI_{t-1}), which is a potentially relevant determinant of the rate of growth of bank net loans, is also incorporated into the baseline model.

All bank-specific characteristics and macroeconomic control variables (except for a recession dummy) are lagged one period to mitigate the potential problem of endogeneity. The lagged dependent variable ($L_{i,t-1}$) is also added to allow for the presence of autoregressive process, that is the AR(1) term is included. Additionally, all regressions include a constant term and yearly dummies (Y_h) in order to control for annual effects and for time trend in variables and their potential shifts. The specification of the baseline model in the present study is thus given by:

$$L_{i,t} = \beta_0 + \beta_1 L_{i,t-1} + \beta_2 CAP_{i,t-1} + \beta_3 LIQ_{i,t-1} + \sum_{l=1}^{k} \gamma_l X_{li,t-1} + \delta_1 \Delta GDP_{t-1} + \varphi R_t$$
$$+ \delta_2 \Delta INT_{ST\,t-1} + \delta_3 CPI_{t-1} + \delta_4 MPI_{j,t-1} + \sum_{h=2011}^{2018} \theta_h Y_h + \alpha_i + \varepsilon_{it} \quad (4.1)$$

Where *i* refers to the individual bank number, *t* denotes the annual time dimension and *j* is a subscript for countries.

The dependent variable ($L_{i,t}$) is the net loans growth rate of bank *i* in period *t*. A vector variable X_l denotes a k-dimensional vector of bank-specific characteristics that includes a bank size (logarithm of total assets, *Lsize*); a bank profitability proxy (i.e., return on assets, *ROA*); the market funding ratio (non-deposit liabilities to asset ratio, *MFUND*); the ratio of net loans to total customer deposits (*LTD*); and a proxy for the bank balance sheet strength and loan portfolio quality, namely loan loss provisions as a percentage of total gross loans (*Provisions*). A component β_0 denotes a constant term and α_i represents bank-specific fixed effects that capture the unobserved heterogeneity, i.e., unobserved characteristics that vary across banks.

Table 4.1. Expected signs in relationships between main regressors and the dependent variable

Variable name	Variable description	Expected sign	Basic argument
CAP	Capital ratio (Tier 1 ratio, TCR, ECR)	+/-	According to the relevant literature, the expected sign of capital effect on lending is ambiguous. On the one hand, it is expected that the relationship between bank capital and loans growth is positive since the more capital a bank has the larger its loss-bearing and risk-absorbing capacity becomes, and thus the more loans it can safely create (Kim and Sohn, 2017, pp. 97-98). However, if the financial fragility theory and the "crowding out" effect prevails and dominates the "risk-absorption" effect, the link between bank loans growth and the capital ratio can be negative (Berger & Bouwman, 2009, pp. 3783-3784).
LIQ	Liquidity ratio (LADSTF: liquid assets to customer deposits and short-term funding ratio; LATDB: liquid	+	The liquid assets act as a safety buffer against the liquidity risk, i.e. risk of a considerable outflow of short-term funding and risk of withdrawal of customer deposits in particular (in an extreme case: risk of a bank run). Therefore, banks that hold more liquid assets in

	assets to deposits and borrowing ratio)		relation to their short-term liabilities are exposed to less liquidity risk and can thus supply more loans and extend more credit.
Other bank-specific variables			
Lsize	Bank size (measured as a logarithm of total assets)	+/-	The expected sign of the bank size impact on lending is ambiguous. Small banks contract their loan portfolios more rapidly in downturns compared to large banks. However, the latter are more likely to rely on the wholesale market funding which is less expensive source of funding and thus they can more profitably supply loans in booms. As a result, the effect of bank size on lending depends on the state of the economic cycle. Moreover, according to the 'too big to fail' theory, large banks can supply more loans as they tend to take more risk, expecting the government to bail them out to prevent a systemic financial crisis (from this viewpoint, the size effect is positive). However, small banks which often purse only traditional banking tend to focus on lending activities instead of investment and underwriting operations, which suggests that the expected sign of bank size effect is negative.
ROA	Bank profitability (return on assets)	+	As is formally demonstrated in the first chapter of the present thesis, more profitable environment creates incentives for banks to lend more. As a result, the expected effect of bank profitability on lending is positive.
MFUND	Market funding ratio (non-deposit liabilities to total assets ratio)	+/-	The expected sign is ambiguous since it seems to depend on the bank size (Kim & Sohn, 2017, p. 100). Large banks have an easier access to (wholesale) market funding due to their market position, and as a result, they tend to rely more heavily on this relatively cheap source of funding, and in particular on the interbank reserve market (hence the sign should be positive for large banks and negative for small). However, this market-oriented funding structure implies higher market and funding liquidity risk, therefore it can lower the growth of loans, especially in recessionary periods (Brei et al., 2013, p. 495).
LTD	Loans to deposits ratio	-	The expected sign is negative. The balance-sheet structure of banks with higher loan-to-deposit ratio, which involves more risk and less bank liquidity, is expected to render them less willing to provide new loans or extend credit.
Provisions	Bank loan-loss provisions to gross loans	-	The expected sign is negative because banks with higher position of loan loss provisions tend to expect a deterioration in the quality of

			their loan portfolios and, in consequence, are likely to supply fewer loans (Kim & Sohn, 2017, p. 101; Małgorzata Olszak, Chodnicka-Jaworska, Kowalska, & Świtała, 2018, p. 1678). Deterioration in the quality of loan portfolio also implies a weaker bank balance sheet, a worse market position and declining bank profits.
Macroeconomic control variables			
ΔGDP	Real GDP growth	+	The effect of real economic growth on lending activity is expected to be positive due to inherent procyclicality of bank lending activities (Olszak, 2015). Higher GDP growth increases both households' and firms' demand for loans, and also encourages banks to lend more as it becomes less risky (as borrowers becomes more creditworthy) and more profitable (as collateral and net worth rise).
ΔINT_ST	Change in the nominal short-term interest rate	-	The impact of changes in the nominal interest rate on bank lending is regarded as negative because the higher market rate of interest the lower the demand for loans (Kim & Sohn, 2017, p. 101). Moreover, high interest rates at the same time can decrease the value of borrowers' collateral and their net worth.
CPI	Consumer Price Index	+	Nominal rise in prices is expected to increase nominal level of bank lending. Higher inflation of consumer prices, which is associated with stronger economic growth, can stimulate their demand for bank loans.
MPI	Macroprudential policy index	+/-	The expected sign is ambiguous since, on the one hand, more restrictive macroprudential policy is likely to inhibit growth of bank loans. On the other hand, stricter and better macroprudential toolkit (i.e., more numerous macroprudential instruments such as: DTI ratio limit, LTV caps or concentration limits) is associated with a higher quality of a country's economic institutions and superior macroeconomic policy in general. All of which creates a safer and more stable environment for bank lending growth.
R	Recession in the euro area dummy	-	Economic downturn and recessions are naturally periods associated with slower bank loans growth. Thus, the expected effect of the 2011-2013 recession on the Europeans banks' lending is negative.

Source: own elaboration.

Results of the baseline fixed-effects regression (specification of 4.1) for three distinct measures of bank capital ratio and two different types of dependent variable are presented in Table 4.2. Columns 1, 2 and 3 report the main effects of capital ratios on the 'net loans (growth of logarithm)' (*DLloans*) and columns 4, 5, 6 present the main effects of capital ratios on the 'net loans growth rate' (*dloans*). As Table 4.2. shows, both statistical significance (denoted by a number of stars) and magnitudes of the estimated coefficients are in close proximity for both types of dependent variable. On average, models with the net loan growth of logarithm as a dependent variable have higher values of the adjusted (within-group) R-squared statistics, which suggests that they ensure a better fit to the actual data than regressions with the alternative dependent variable.

The expectations with regard to the signs of coefficients are mostly supported by the estimates of the baseline model. First, the regulatory capital requirements (Tier 1 ratio and TCR – columns 1, 2 and 4, 5 in Table 4.2.) exert a significantly positive effect on bank lending, while the equity capital ratio impacts the net loans growth negatively (see columns 3 and 6). This difference might be a result of a non-linear relationship between bank capital and loans growth. This observation would support the positive answer to Research question 1 about the non-linearity in the studied relationship between capital ratios and bank loans growth in the period 2011-2018 for the sample of European banks. The nonlinearity, however, may arise also due to the fact that relevant interaction terms or some important factors are not included in the baseline regression model[61]. Furthermore, a negative sign of the ECR's coefficient may indicate that it is less binding a capital measure than risk-based regulatory minimum capital requirements, such as the tier 1 ratio and total capital ratio, which are positively associated with bank loans growth, and thus can more effectively be a constraint on European bank lending activities. The fact that two out of three used measures of a capital ratio exert a significantly positive effect on bank lending largely support the positive answer to Research question 2.

Second, in all regressions, effects of liquidity ratio on bank loans is positive and statistically significant even at one percent statistical level. This evidence strongly supports my prior expectations. The positive liquidity effect (LIQ_{t-1}) varies only to a very limited extent: a 1 percentage point increase in the liquidity ratio causes *ceteris paribus* a

[61] Both of these issues are addressed in the next Sections of this Chapter.

higher net loans growth by between 0.40-0.49 percentage points in a year, depending upon the definition of capital ratio (CAP_{t-1}) and the adopted dependent variable (L_t).

Among the coefficients of bank-specific characteristics only bank size (Lsize_{t-1}) and market funding ratio (MFUND_{t-1}) are consistently negative and significant (except for the size effect in column 4) which confirms my initial expectations. A general implication of this is that large banks exhibit, on average, significantly lowered growth in their net loans in comparison to small banks, all other things being equal. Similarly, banks that rely extensively on the outside market funding provide fewer loans *ceteris paribus* in the 2011-2018 period (full sample). Return on assets (ROA_{t-1}), a proxy for bank profitability, loan loss provisions ($\mathrm{Provisions}_{t-1}$) and the ratio of loans to deposits (LTD_{t-1}) are not significant determinants of the European banks' lending, according to the baseline model.

In all regressions, the real economic growth ($\Delta\mathrm{GDP}_{t-1}$) exerts a significantly positive effect on bank lending activities, as was expected. A one-percentage-point increase in the real GDP growth is associated with approximately between 1.15-3.88 percentage points increase in the annual growth of bank loans. This baseline model's result clearly indicates an inherent procyclicality of bank lending operations.

Significant and positive coefficients associated with effects of interest rate changes on loans growth indicate, contrary to my initial expectations, that nominal interest rates are also a procyclical component that positively impacts lending in a year. It may be explained on the grounds that higher nominal interest rates allow banks to charge borrowers with higher lending rates, while keeping low (interbank) market borrowing rates. That in turn would make bank lending more profitable, especially during the final phase of a boom.

In line with the initial expectations, a nominal index of consumer prices (CPI_{t-1}) is positively associated with the growth of net loans. This effect is statistically significant and positive in all regressions. A one-percentage-point increase in the general level of prices causes *ceteris paribus* between 1.73-3.53 percentage points increase in the annual growth of bank loans in one year, depending upon the definition of capital ratio (CAP_{t-1}) the adopted dependent variable (L_t).

A recession dummy in the euro area (R_t) is not consistently significant and has a varying sign across regressions. Effects of the macroprudential policy restrictiveness index ($\mathrm{MPI_{t-1}}$) on bank loans growth is largely significant and positive. The baseline model's result suggests, as is argued in Table 4.1., that a stricter and more numerous macroprudential toolkit can indeed be associated with a higher quality of economic institutions and a superior macroeconomic policy in general. This in turn is conductive to a stable and resilient growth of bank lending across the business and financial cycles (see the basic arguments in Table 4.1).

Table 4.2. Baseline regression results

	L_t = **Net loans (growth of logarithm)**			L_t = **Net loans growth rate**		
	Tier 1 capital /RWA	Total capital /RWA	Equity capital / total assets	Tier 1 capital /RWA	Total capital /RWA	Equity capital /total assets
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{L_{t-1}}$	0.029 (0.037)	0.038 (0.042)	0.044 (0.036)	0.025 (0.038)	0.026 (0.044)	0.046 (0.037)
$\mathbf{CAP_{t-1}}$	0.444*** (0.169)	0.399*** (0.146)	-0.574*** (0.222)	0.581** (0.247)	0.483** (0.192)	-0.540** (0.244)
$\mathbf{LIQ_{t-1}}$	0.417*** (0.078)	0.403*** (0.062)	0.437*** (0.056)	0.474*** (0.091)	0.431*** (0.071)	0.485*** (0.071)
$\mathbf{Lsize_{t-1}}$	-9.341** (4.339)	-11.838*** (4.189)	-19.815*** (4.015)	-8.380 (5.330)	-11.130** (4.790)	-19.271*** (4.564)
$\mathbf{ROA_{t-1}}$	0.513 (1.036)	-0.519 (0.745)	0.064 (0.570)	0.428 (1.281)	-0.231 (0.936)	0.055 (0.674)
$\mathbf{MFUND_{t-1}}$	-0.350*** (0.071)	-0.289*** (0.076)	-0.217** (0.085)	-0.396*** (0.087)	-0.330*** (0.085)	-0.230** (0.103)
$\mathbf{LTD_{t-1}}$	-0.648 (0.645)	-1.483** (0.694)	-0.858 (0.575)	-0.729 (0.763)	-1.370** (0.692)	-1.032* (0.612)
$\mathbf{Provisions_{t-1}}$	0.467 (0.482)	0.195 (0.364)	-0.345 (0.302)	0.462 (0.634)	0.398 (0.488)	-0.261 (0.393)
$\mathbf{\Delta GDP_{t-1}}$	3.055*** (0.578)	2.005*** (0.401)	1.154*** (0.326)	3.884*** (0.883)	2.717*** (0.553)	1.533*** (0.399)
$\mathbf{\Delta INT\_ST_{t-1}}$	0.709 (0.804)	1.524** (0.666)	1.239** (0.577)	0.707 (0.911)	1.516** (0.742)	1.545** (0.636)
$\mathbf{CPI_{t-1}}$	3.123*** (0.685)	1.734*** (0.515)	1.843*** (0.449)	3.526*** (0.835)	1.976*** (0.601)	1.850*** (0.521)
$\mathbf{R_t}$	5.265** (2.389)	-3.058 (1.893)	-2.776* (1.582)	6.494** (2.829)	-3.384 (2.102)	-2.657 (1.799)
$\mathbf{MPI_{t-1}}$	3.654*** (0.859)	0.755 (0.641)	2.242*** (0.616)	3.862*** (1.005)	0.490 (0.723)	2.379*** (0.695)
Observations	4,931	5,586	8,063	4,931	5,587	8,065
Adjusted $\mathbf{R^2}$	0.212	0.183	0.152	0.203	0.175	0.142

No. of panels	1,350	1,530	2,022	1,350	1,530	2,023

Notes: The table reports estimated coefficients and statistics from fixed effects regression. Robust standard errors, clustered at the individual bank level, are reported in parentheses. All regressions include a constant term and yearly dummies, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. LIQ_{t-1} is a one-period lagged ratio of liquid assets to short-term funding (LADSTF). RWA denotes bank risk-weighted assets.
Source: own elaboration.

Prior to any further analysis of more complex regression models and more detailed issues, it is worth examining whether the applied fixed-effects estimator is actually preferable according to the standard Durbin–Wu–Hausman (DWH) test, widely regarded as the Hausman (1978) specification test. The results of this test and other relevant statistics, such as statistics from the Hausman test and Breusch and Pagan's (1980) Lagrange multiplier (LM) test for random effects, are reported in Table 4.3.

It is worth noting that the applied diagnostics procedure has produced six distinct models for two estimators (fixed and random effects) and three different measures of a capital ratio. The three additional random-effects models can be therefore seen as the first of many checks for robustness of obtained results. Differences and similarities between six estimated models are presented in Table 4.3 in case of the baseline regression specification; and in Table 4.5 in Section 4.2 in the case of the interactive regression model.

Table 4.3. Hausman and Breusch–Pagan tests' results in the baseline regression model

	Tier 1 capital /RWA		Total capital /RWA		Equity capital /total assets	
Estimation method	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects	Random effects
$\mathbf{L_{t-1}}$	0.029	0.199***	0.038	0.208***	0.044	0.219***
$\mathbf{CAP_{t-1}}$	0.444***	0.005	0.399***	-0.005	-0.574***	-0.229***
$\mathbf{LIQ_{t-1}}$	0.417***	0.084***	0.403***	0.060***	0.437***	0.073***
$\mathbf{Lsize_{t-1}}$	-9.341**	0.532**	-11.838***	0.687***	-19.815***	0.404***
$\mathbf{ROA_{t-1}}$	0.513	-0.444	-0.519	-0.533	0.064	0.285
$\mathbf{MFUND_{t-1}}$	-0.350***	-0.031	-0.289***	-0.016	-0.217**	-0.048**
$\mathbf{LTD_{t-1}}$	-0.648	-0.551	-1.483**	-0.662**	-0.858	-0.213
$\mathbf{Provisions_{t-1}}$	0.467	0.062	0.195	0.060	-0.345	-0.129

$\mathbf{\Delta GDP_{t-1}}$	3.055***	0.604*	2.005***	-0.382	1.154***	-0.744***
$\mathbf{\Delta INT\_ST_{t-1}}$	0.709	4.550***	1.524**	4.251***	1.239**	4.216***
$\mathbf{CPI_{t-1}}$	3.123***	-0.987***	1.734***	-1.306***	1.843***	-1.324***
$\mathbf{R_t}$	5.265**	5.379***	-3.058	-0.076	-2.776*	0.181
$\mathbf{MPI_{t-1}}$	3.654***	3.255***	0.755	2.207***	2.242***	1.718***
Observations	4,931	4,931	5,586	5,586	8,063	8,063
Adjusted R^2	0.212	0.169	0.183	0.180	0.152	0.187
Hausman test Chi-square statistics	H0: RE is efficient $\chi^2 = 912.67$ *p*-value = 0.00		H0: RE is efficient $\chi^2 = 1081.65$ *p*-value = 0.00		H0: RE is efficient $\chi^2 = 1630.80$ *p*-value = 0.00	
Breusch-Pagan test for random effects	H0: no random effects $LM = 5.35$ *p*-value = 0.01		H0: no random effects $LM = 13.96$ *p*-value = 0.00		H0: no random effects $LM = 5.10$ *p*-value = 0.01	

Notes: The table reports baseline model coefficients and statistics from fixed effects and random effects regression. In both estimations, robust standard errors, clustered at the individual bank level, are applied but not reported in the table. All regressions include a constant term and yearly dummies, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. The dependent variable is the net loans growth of logarithm (*DLloans*). Adjusted R-squared reported in this table is the within R-squared statistic in the case of fixed-effects estimator and the overall R-squared statistic for random-effects method.
Source: own elaboration.

As Table 4.3. shows, the Hausman test consistently rejects the null hypothesis of random-effects model being efficient and unbiased in all regressions, i.e., for three different capital ratios. Thus, the conclusion is that the difference between coefficients estimated by RE and FE estimators is significant and systematic. This result suggests using the fixed effects estimation, because the FE estimator is consistent both under the null and alternative hypotheses, unlike the random effects estimator which is efficient under the null hypothesis but is inconsistent if it does not hold, as in the present case.

Regarding the Breusch-Pagan test's results, the LM statistics are high in all cases which suggests that the random effects are present, and hence that RE estimator would be more efficient than pooled ordinary least squares (OLS), which would suggest the use of RE estimator (see the last row in Table 4.3). However, as Brei et al. (2013) emphasize, if the final sample is not randomly drawn from a given population, the random effects model should be abandoned in favor of fixed effects estimator (see also Dougherty, 2011, pp. 525-526). This is clearly the case of the Bank Orbis Focus database because it contains information on well-established (often listed) banks, and thus it does not represent a randomly drawn sample from the population of European banks. In addition, as Table 4.3. reports, according to the Hausman test's results, the unobserved effect is not distributed independently of the regressors, that is $Cov\left(\mu_i, X_j\right) \neq 0$, hence the main underlying assumption of the random effect estimator is not valid (see Section 3.1.2 for details of this issue).

In general, all of the obtained evidence tends to suggest using the fixed effects estimator. Another argument in favor of fixed effects method is the fact that it is widely used in financial and bank-related studies. The panel data fixed effects estimation as an empirical method has been extensively used in the relevant literature (see, for example, Berrospide & Edge, 2010; Cornett, McNutt, Strahan, & Tehranian, 2011; Francis & Osborne, 2012; Kim & Sohn, 2017; Thornton & Tommaso, 2020).

4.2 Interactive model with effects of capital, liquidity and QE dummy

The interaction-based approach to measuring an influence of a specific factor in studied relationships is a standard practice in the literature (cf. Beatty and Liao, 2011; Olszak et al., 2016; Kim and Sohn, 2017). In this section, the baseline model is extended to include the impact of the central bank quantitative easing policy (QE) operationalized as a binary variable. Thereby the baseline model is transformed into an interaction-based or interactive model (henceforth preferably termed an "interactive model", see also Burks, Randolph, & Seida, 2019).

The first adjustment to the baseline model is an incorporation of a dummy variable representing an impact of the ECB's QE policy, namely of the Asset Purchase Program on studied relationship, into the regression specification of the interactive model. A relevant interaction term between the APP dummy (APP_d) and a bank capital ratio ($CAP_{i,t}$) is included to capture the impact of this unconventional monetary on the link between bank loans growth and a capital ratio[62]. The interactive model thus incorporates a new interaction component ($CAP_{i,t} \times APP\_d_{j,t}$).

[62] The names 'QE dummy' and 'APP dummy' henceforth will be used interchangeably. They both relate to the ECB's Quantitative Easing policy in the form of Asset Purchase Program's (APP) net purchases conducted by the Eurosystem. The APP was initiated in mid-2014 and net purchases under the program continued until December 2018.

The second innovation of the interactive model is adding moderating effects of liquidity to the relationship between bank capital and loans. The model thus includes an interaction between bank capital and liquidity ($CAP_{i,t} \times LIQ_{i,t}$). As Kim & Sohn (2017) demonstrated, there is “a significant interaction effect of bank capital and liquidity on credit supply for large banks” (Kim & Sohn, 2017, p. 96). In short, liquidity matters for any analysis of the effect of bank capital on lending which takes bank size into consideration. Additionally, an interaction between bank liquidity and the QE policy ($LIQ_{i,t} \times APP\_d_{j,t}$) is added to account for potentially significant effects of the QE policy on bank loans growth via bank relative liquidity level. Lastly, to capture a joint effect of liquidity, capital and the QE policy on bank lending, a relevant triple interaction term ($CAP_{i,t} \times LIQ_{i,t} \times APP\_d_{j,t}$) is included in the interactive model. The triple interaction component measures how much the elasticity of lending with respect to a capital ratio changes with the introduction of the APP program in Europe for different degree of bank liquidity.

Extending the baseline model while taking into consideration all above adjustments, the empirical specification of the interactive model is given by:

$$\begin{aligned} L_{i,t} = \beta_0 &+ \beta_1 L_{i,t-1} + \beta_2 CAP_{i,t-1} + \beta_3 LIQ_{i,t-1} + \beta_4 CAP_{i,t-1} \times LIQ_{i,t-1} \\ &+ \beta_5 CAP_{i,t-1} \times APP\_d_{j,t} + \beta_6 LIQ_{i,t-1} \times APP\_d_{j,t} \\ &+ \beta_7 CAP_{i,t-1} \times LIQ_{i,t-1} \times APP\_d_{j,t} + \sum_{l=1}^{k} \gamma_l X_{li,t-1} + \delta_1 \Delta GDP_{t-1} \\ &+ \varphi R_t + \delta_2 \Delta INT\_ST_{t-1} + \delta_3 CPI_{t-1} + \delta_4 MPI_{j,t-1} + \sum_{h=2011}^{2018} \theta_h Y_h \\ &+ \alpha_i + \varepsilon_{it} \end{aligned} \tag{4.2}$$

where *i* as before refers to the individual bank number, *t* denotes the annual time dimension and *j* represents an index for countries.

The interaction term between the QE and a capital ratio is associated with coefficient β_5 which is the most important coefficient to be estimated because it points to the moderating impact of the ECB’s APP policy on the link between bank loans growth and the capital ratio. In line with Hypothesis 1, it is expected that the sign of this parameter is negative so that the effect of bank capital ratios on bank lending is in general negatively associated with the Quantitative Easing policy of the ECB in Europe. The underlying mechanism assumes that banks that engage in the APP assets sales (purchases from the central bank's viewpoint) with the ECB improve their relative liquidity and capital situation, and as a result they become less liquidity constrained and less capital constrained. This negative effect can be amplified if this unconventional policy also reduces bank profitability and at the same time increases balance sheet costs (Demertzis & Wolff, 2016; Horst & Neyer, 2019).

This expectation is formulated in line with research findings of Kim and Sohn (2017) for US banks and Thornton and Tommaso (2020) for European banks who all demonstrated that the impact of liquidity increases (or, in the present study: liquidity injections in the form of QE policy) on the link between capital ratio on bank lending is negative for banks with low liquidity ratios but positive for large banks that retained sufficient level of liquid assets. Thus, the bank size and liquidity concerns matter.

As Thornton and Tommaso (2020) concluded, "[bank] capital exerts a significantly positive effect on European banks' credit and lending growth [only] after they retain sufficient liquid funds" (Thornton & Tommaso, 2020, p. 6). Consistently with Hypothesis 2, the effect of an increase in bank capital on loans growth is therefore expected to be positively associated with the QE policy activation (which increases liquidity levels) for large banks with relatively high liquidity. It should be especially pronounced for large banks and when they "retain sufficient liquid assets" (Kim and Sohn, 2017, p. 102), although the final marginal effect of QE policy and capital ratio on bank lending can also be dependent on the phase of the economic cycle, as these authors suggest[63] (ibid., p. 107).

Table 4.4. Interaction effects of capital, liquidity and APP dummy on bank loans growth

	L_t = Net loans (growth of logarithm)			**L_t = Net loans growth rate**		
	Tier 1 capital /RWAs	Total capital /RWAs	Equity capital/ Total assets	Tier 1 capital /RWAs	Total capital /RWAs	Equity capital/ Total assets
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{L_{t-1}}$	0.039 (0.037)	0.043 (0.042)	0.047 (0.036)	0.029 (0.039)	0.026 (0.045)	0.049 (0.038)
$\mathbf{CAP_{t-1}}$	-0.187 (0.193)	-0.023 (0.174)	-0.570** (0.282)	-0.216 (0.223)	-0.034 (0.207)	-0.533* (0.300)
$\mathbf{LIQ_{t-1}}$	0.346**	0.348***	0.519***	0.346*	0.361***	0.579***

[63] The expected sign on other variables of the interactive model are basically the same as in the baseline model.

	(0.142)	(0.120)	(0.076)	(0.181)	(0.140)	(0.106)
$\mathbf{Lsize_{t-1}}$	-9.872** (4.319)	-12.676*** (4.187)	-19.298*** (4.052)	-8.777* (5.234)	-11.693** (4.766)	-18.677*** (4.476)
$\mathbf{ROA_{t-1}}$	0.854 (1.010)	-0.450 (0.724)	0.097 (0.561)	0.845 (1.234)	-0.117 (0.896)	0.099 (0.657)
$\mathbf{MFUND_{t-1}}$	-0.342*** (0.073)	-0.267*** (0.078)	-0.214** (0.087)	-0.392*** (0.088)	-0.312*** (0.087)	-0.226** (0.105)
$\mathbf{LTD_{t-1}}$	-0.602 (0.603)	-1.401** (0.662)	-0.626 (0.415)	-0.661 (0.708)	-1.276* (0.659)	-0.758* (0.415)
$\mathbf{Provisions_{t-1}}$	0.539 (0.477)	0.235 (0.365)	-0.313 (0.304)	0.547 (0.635)	0.438 (0.488)	-0.220 (0.398)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}}$	0.008*** (0.002)	0.004* (0.002)	0.000 (0.002)	0.010*** (0.003)	0.004* (0.002)	0.000 (0.002)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP\_d}$	0.445** (0.174)	0.336** (0.153)	0.391 (0.240)	0.472*** (0.182)	0.352** (0.168)	0.432 (0.288)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.208 (0.167)	-0.142 (0.138)	-0.129** (0.063)	-0.264 (0.199)	-0.226 (0.161)	-0.150* (0.082)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.006 (0.006)	-0.005 (0.005)	-0.006 (0.004)	-0.004 (0.007)	-0.002 (0.006)	-0.007* (0.004)
Observations	4,931	5,586	8,063	4,931	5,587	8,065
Adjusted $\mathbf{R^2}$	0.244	0.200	0.160	0.233	0.189	0.150
No. of panels	1,350	1,530	2,022	1,350	1,530	2,023

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. All regressions include a constant term, yearly dummies and macroeconomic control variables, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. $\mathrm{LIQ_{t-1}}$ is a one-period lagged ratio of liquid assets to short-term funding (LADSTF). RWAs denotes bank risk-weighted assets.
Source: own elaboration.

In models with an interaction term, coefficients do not represent an expected marginal (the main) effect as in linear-additive model but a conditional marginal effect. The sign and magnitude of the latter strictly depends on the level of other variables. As Burks, Randolph, & Seida (2019) underline, this interpretation applies "to any research that uses interactions to examine whether the effect of one explanatory variable depends on another" (Burks et al., 2019, p. 62).

The above fact can be formally demonstrated by taking a partial derivative of the dynamic, interactive Equation 4.2. with respect to a bank capital ratio. This operation yields:

$$\frac{\partial L_{i,t}}{\partial CAP_{i,t-1}} = \beta_2 + \beta_4 \times LIQ_{i,t-1} + \beta_5 \times APP\_d_{j,t} + \beta_7 \times LIQ_{i,t-1} \times APP\_d_{j,t} \qquad (4.3)$$

Where the left-hand-side term ($\partial L_{i,t} / \partial CAP_{i,t-1}$) denotes a partial derivate of bank loans growth with respect to a one-period-lagged capital ratio.

Using Equation 4.3. and the estimates contained in Table 4.4., the conditional marginal effect of the equity capital ratio (ECR; that is, column 3) on bank lending, for a median value of liquidity ratio (that equals 19.36 in the ECR specification) and for a bank from a country subjected to the QE policy ($APP\_d_{j,t} = 1$), is equal to -0.295, using the approximate values[64] of the relevant coefficients from Table 4.4. The conditional marginal effect of ECR on bank lending is reduced by approximately -0.277 percentage points (and equals -0.576) for a bank that is not subjected to the QE policy at the median level of bank liquidity ratio. Therefore, in case of the ECR, the conditional effect of capital ratio on bank loans growth is still significant and negative (as in the baseline model) but the QE impact is not statistically significant. The QE effect diminishes as bank liquidity increases (see the bottom diagram in Figure 4.1).

In the cases of Tier 1 and the total capital ratio the conditional constituent effect of capital on bank lending, measured by parameter β_2 in Equation 4.2, is positive but insignificant. However, the interactive coefficient on $CAP_{i,t-1} \times APP\_d_{j,t}$, measured by parameter β_5 in Equation 4.2, is significantly positive for both the Tier 1 and TCR ranging from approximately 0.34 to 0.47 (see columns 1, 2 and 4, 5 in Table 4.4.). The results indicate that in the case of regulatory binding capital ratios the general relationship between capital ratios and bank loans growth is positive for liquid banks (with a level of liquidity ratio above the median), and the activation of QE asset purchases only elevates this positive effect in a statistically significant way (see the upper diagrams in Figure 4.1.). The interpretation of this result is that QE policy elevates the effects of 1-percentage-point increase in the regulatory Tier 1 capital ratio on the bank loans growth

[64] This number is calculated as follows: -0.570+0.00*19.36 + 0.391*1 + (-0.006*19.36*1). The applied statistical software (STATA) reports a more precise value of the conditional marginal effect of capital as being equal to -0.2992. This precise value is also reflected in Figure 4.1. for a median level of liquidity ratio that equals 19.36 in the case of regression with ECR as a capital ratio.

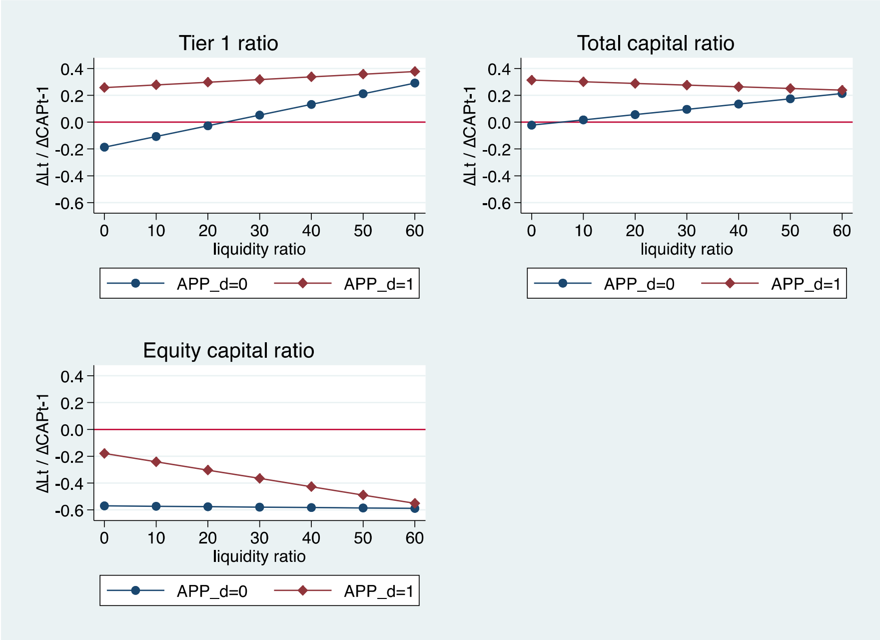
by approximately 0.37 percentage points in a year for the median-liquidity bank[65]. Similarly, the ECB's QE policy elevates the effects of 1-percentage-point increase in the regulatory Total capital ratio on the growth of bank loans by approximately 0.27 percentage points in one year for the median-liquidity bank[66]. These empirical results do not support Hypothesis 1 which states that the effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB.

Consistently with the case of the equity capital ratio, in regressions with Tier 1 and TCR as a capital ratio the QE effect diminishes as bank liquidity increases. This evidence seems to suggest that the economic impact of the unconventional monetary policy in the form of the ECB's APP program could be larger for less liquid banks, providing evidence that such policy removes the liquidity constraint on their lending. This empirical result largely confirms Hypothesis 2 which states that effect of bank capital ratios on bank lending is positively associated with the ECB's QE policy only for large banks with sufficient level of liquidity. However, a closer examination of bank-specific factors as interaction constituents in the next Sections of the present thesis will allow to draw final conclusions.

In any case the positive sign of the QE's impact is confirmed because the QE activation shifts the marginal effect curve upward across all three capital ratios (see Figure 4.1.). However, the QE policy has only limited effect on more liquid banks because with increasing liquidity levels banks become only slightly more responsive to capital ratio shocks, i.e., the slope of the marginal effect curve flattens for banks subjected to QE. This evidence points to a possibility that QE policy has been successful in removing the liquidity constraint for less liquid banks, but on the other hand, it has made them less resilient (i.e., more responsive) to capital shocks. The Figure 4.1. shows the described elasticity, that is the responsiveness of bank loans growth with respect to bank capital ratios for all three measures of bank capital.

[65] The median level of liquidity ratio equals 11.68 in the case of the regression with Tier 1 ratio as a capital ratio.
[66] The median level of liquidity ratio equals 13.40 in the case of the regression with TCR as a capital ratio.

Figure 4.1. Elasticity of bank net loans growth with respect to bank capital ratios



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to a lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. Marginal effects of key capital ratios are calculated based on coefficients drawn from Table 4.4.
Source: own elaboration.

Interpretation of other interaction terms is somewhat more complicated. An interaction between liquidity and the QE policy ($LIQ_{i,t-1} \times APP\_d_{j,t}$) is negative across all capital ratios but is significant only in the case of ECR. This evidence supports the notion that ECB's assets purchases have indeed made banks less depended on liquidity and hence less constrained by it. The coefficients on the triple interaction term ($CAP_{i,t-1} \times LIQ_{i,t-1} \times APP\_d_{j,t}$) turn out to be negligibly small and insignificant in almost all cases, except for the ECR and the net loans growth rate used as a dependent variable. Positive and significant estimates of coefficients on $CAP_{i,t-1} \times LIQ_{i,t-1}$ confirm the previous findings of Kim & Sohn (2017) and Thornton & Tommaso (2020), suggesting that effects of capital ratios on bank loans growth are positively associated with the level of bank liquidity.

Table 4.5. Hausman and Breusch–Pagan tests' results in the interactive regression model

	Tier 1 capital /RWA		Total capital /RWA		Equity capital /total assets	
Estimation method	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects	Random effects
$\mathbf{L_{t-1}}$	0.039	0.194***	0.043	0.205***	0.047	0.219***

$\mathbf{CAP_{t-1}}$	-0.187	-0.282***	-0.023	-0.195***	-0.570**	-0.307***
$\mathbf{LIQ_{t-1}}$	0.346**	-0.004	0.348***	0.020	0.519***	0.092***
$\mathbf{Lsize_{t-1}}$	-9.872**	0.323	-12.676***	0.453**	-19.298***	0.395**
$\mathbf{ROA_{t-1}}$	0.854	-0.045	-0.450	-0.326	0.097	0.333
$\mathbf{MFUND_{t-1}}$	-0.342***	-0.050*	-0.267***	-0.025	-0.214**	-0.051**
$\mathbf{LTD_{t-1}}$	-0.602	-0.383	-1.401**	-0.569*	-0.626	-0.180
$\mathbf{Provisions_{t-1}}$	0.539	0.182	0.235	0.129	-0.313	-0.099
$\mathbf{CAP_{t-1} \times LIQ_{t-1}}$	0.008***	0.003***	0.004*	0.002	0.000	0.000
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP\_d}$	0.445**	0.238***	0.336**	0.176***	0.391	0.248***
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.208	0.071	-0.142	0.056	-0.129**	-0.017
$\mathbf{CAP_{t-1} \times LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.006	-0.002	-0.005	-0.002	-0.006	-0.003*
Observations	4,931	4,931	5,586	5,586	8,063	8,063
Adjusted R^2	0.244	0.177	0.200	0.182	0.160	0.189
Hausman test Chi-square statistics	H0: RE is efficient $\chi^2 = 960.58$ *p*-value = 0.00		H0: RE is efficient $\chi^2 = 1179.84$ *p*-value = 0.00		H0: RE is efficient $\chi^2 = 1724.39$ *p*-value = 0.00	
Breusch-Pagan test for random effects	H0: no random effects $LM = 3.78$ *p*-value = 0.03		H0: no random effects $LM = 11.39$ *p*-value = 0.00		H0: no random effects $LM = 4.30$ *p*-value = 0.02	

Notes: The table reports interactive model coefficients and statistics from fixed effects and random effects regression. In both estimations, robust standard errors, clustered at the individual bank level, are applied but not reported in the table. All regressions include a constant term, yearly dummies and macroeconomic control variables, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. The dependent variable is the net loans growth of logarithm (*DLloans*). Adjusted R-squared reported in this table is the within R-squared statistic in the case of fixed-effects estimator and the overall R-squared statistic for random-effects method.
Source: own elaboration.

Table 4.5. reports the results of the Durbin–Wu–Hausman test, widely known as the Hausman's (1978) specification test, and Breusch and Pagan's (1980) LM test for random effects in case of the interactive regression model.

As Table 4.5. displays, the Hausman test consistently rejects the null hypothesis of random-effects model being efficient and unbiased in all regressions with a different capital ratio. Thus, the conclusion is that the difference between coefficients estimated by RE and FE estimators is significant and systematic. As was the case in the baseline model, the obtained result suggests the use of fixed effects estimation instead of random effects model.

Regarding the Breusch-Pagan test's results, the LM statistics are high enough in all cases which suggests that the random effects are present, and hence that RE estimator would be more efficient than pooled ordinary least squares (OLS), which would suggest the use of RE estimator (see the last row in Table 4.5). However, considering the fact that the main underlying assumption of the random effect estimator is not valid (see Section 3.1.2 for details of the assumption) the optimal choice is to proceed with fixed effects estimator.

Furthermore, as Brei et al. (2013) stressed, if the final sample is not randomly drawn sample from a given population, the random effects model should be abandoned in favor of fixed effects estimator (see also Dougherty, 2011, pp. 525-526). This is clearly the case of the Bank Orbis Focus database, as was already explained in the last part of Section 4.1 devoted to diagnostics of the baseline model.

4.2.1 Interactive model with bank-specific factors

In this section, the interactive model is extended to include bank-specific determinants of the growth of bank loans that could affect the QE policy impact on the relationship between capital ratios and increases in bank lending.

An inclusion of categorical bank-specific variables will allow me to test the empirical Hypothesis 2 and Hypothesis 3 of the present thesis. In the first specification, the categorical variable bank size ($Size\_category_i$)[67] is incorporated into the interactive model described by Equation 4.2. Thus, the new category-augmented regression specification is as follows:

[67] For details on how this categorical variable is constructed, see Table 3.1 in Chapter 3.

$$
\begin{aligned}
L_{i,t} = \beta_0 + \beta_1 L_{i,t-1} + \beta_2 CAP_{i,t-1} + \beta_3 LIQ_{i,t-1} + \beta_4 CAP_{i,t-1} \times LIQ_{i,t-1} \\
+ \beta_5 CAP_{i,t-1} \times Size\_category_i \\
+ \beta_6 CAP_{i,t-1} \times APP_{d\,j,t} \times Size\_category_i + \beta_7 CAP_{i,t-1} \times APP_{d\,j,t} \\
+ \beta_8 CAP_{i,t-1} \times LIQ_{i,t-1} \times Size\_category_i + \beta_9 LIQ_{i,t-1} \times APP_{d\,j,t} \\
+ \beta_{10} CAP_{i,t-1} \times LIQ_{i,t-1} \times APP_{d\,j,t} + \sum_{l=1}^{k} \gamma_l X_{li,t-1} + \delta_1 \Delta GDP_{t-1} \\
+ \varphi R_t + \delta_2 \Delta INT\_ST_{t-1} + \delta_3 CPI_{t-1} + \delta_4 MPI_{j,t-1} + \sum_{h=2011}^{2018} \theta_h Y_h \\
+ \alpha_i + \varepsilon_{it}
\end{aligned}
\qquad (4.4)
$$

Where the size category variable is defined as in Table 3.1. Sign notation of other variables and indexes is the same as in Equations 4.1 and 4.2. The panel fixed-effects estimates of the coefficients and statistics related to the Equation 4.4 are displayed in Table B.1. in Annex.

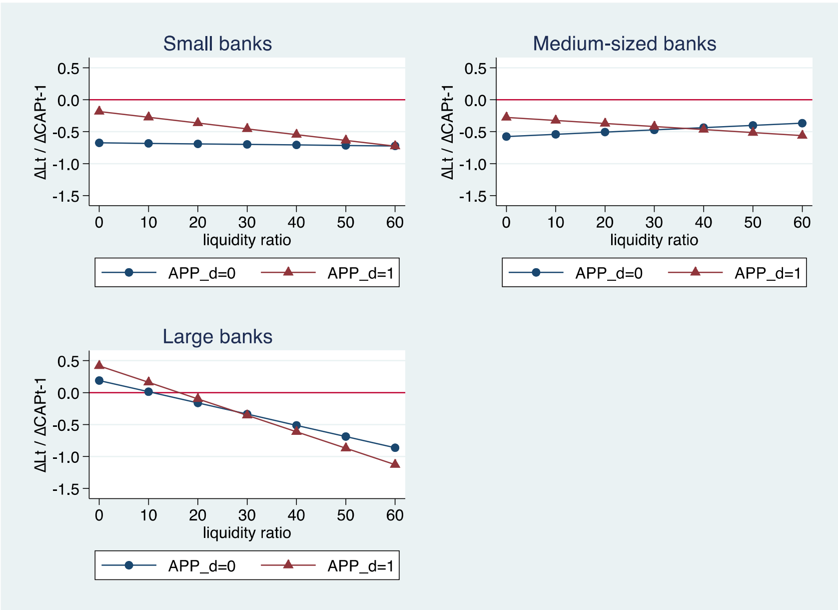
Figure 4.2. shows the marginal effects of the equity capital ratio (ECR) on bank loans growth for different levels of bank liquidity ratio (presented in the horizontal axis) divided into three groups by bank size. The red line with triangles indicates the conditional marginal effect of capital ratio on bank lending for banks from countries subjected to the ECB's assets purchase program, which is captured by the APP dummy ($APP\_d_{j,t}$) when it is equal to one.

The first observation is that marginal effect associated with the ECR for large banks, regardless of their exposure to the QE policy, exhibits qualitatively and quantitively different behavior than those of small and medium-sized banks. In the case of ECR for large banks, two marginal curves are downward sloping. The QE impact is negligible for large banks with liquidity ratio of between 20% and 30%, positive for low liquidity ratio (below the median of 19.36) and negative for highly liquid large banks.

There are three insights gained from the above observations. First, this evidence points to high likelihood that less liquid large banks are more responsive to equity capital ratio in their lending. Second, the relationship between an equity capital ratio and bank loans growth changes in sign and becomes significantly negative after the median level of liquidity is reached (i.e., having approximately 20% of liquid assets to short-term funding and customer deposits). Thirdly, the effect of the equity capital ratio (ECR) on bank lending is positively associated with the Quantitative Easing policy of the ECB for banks with low level of liquidity. As a result, the empirical Hypothesis 2 of the present thesis in the case of the ECR as a capital ratio shall be rejected. An important modification concerning an influence of bank liquidity would make it consistent with the results obtained in the empirical interactive model.

In the case of ECR for small and medium-sized banks the threshold after which the QE policy impact fades away is between 30-40% for medium-sized banks and around 60% for small banks. In addition, similarly to large banks, banks of the medium size are exposed to positive effects of QE policy only when they have very low and medium level of liquidity.

Figure 4.2. Effects of a change in equity capital ratio (ECR) on net loans growth by bank size



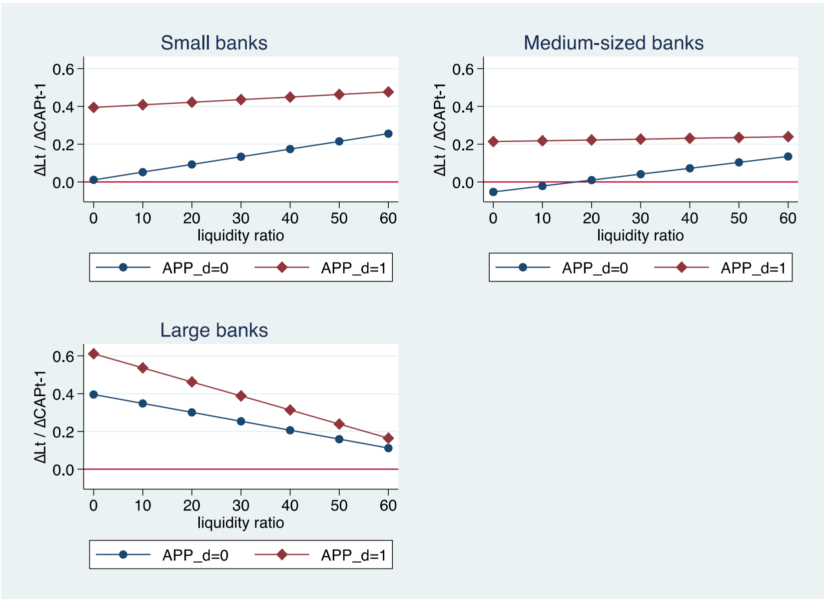
Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 19.36. Marginal effects are calculated based on coefficients drawn from Table B.1. in Annex.
Source: own elaboration.

Estimates for the regulatory Tier 1 and total capital ratios confirm the positive sign of the overall impact of the QE policy on the relationship between capital ratios and bank loans growth in Europe. As both Figure 4.3. and Figure 4.4. demonstrate, banks from countries subjected to QE purchases were more responsive to shocks to capital, as their lending growth sensitivity to capital ratio increases for all considered levels of liquidity.

For the median liquidity levels and for every bank size, the QE policy elevates the effect of a 1-percentage-point increase in capital ratio on the growth of bank loans by approximately 0.19, 0.25 and 0.36 for ECR, TCR and Tier 1 ratio, respectively[68].

This evidence is also confirmed by the estimates of an interaction between a capital ratio and the APP dummy ($CAP_{i,t-1} \times APP_{d\,j,t}$) in Table B.1. This term is a measure of the joint effect of QE and capital ratio on bank lending in the euro area. In every case, except for the ECR regression without bank size category, the coefficients associated with this interaction term are significantly positive. This empirical result is also supported by the visual inspection of Figure 4.3. and Figure 4.4.

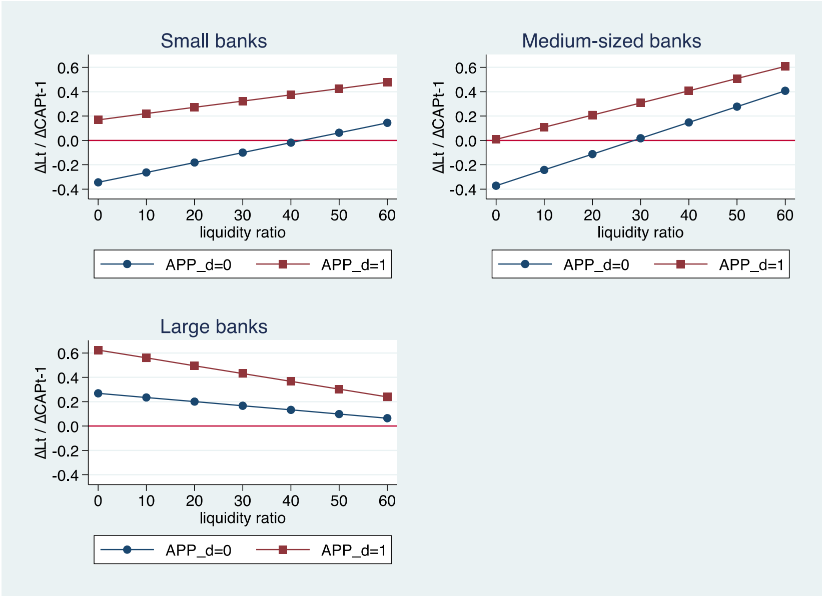
Figure 4.3. Effects of a change in Total capital ratio (TCR) on net loans growth by bank size



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 13.40. Marginal effects are calculated based on coefficients drawn from Table B.1. in Annex.
Source: own elaboration.

[68] That is, the average marginal effect of the APP dummy increases from -0.52 to -0.33 for ECR, from 0.06 to 0.31 in the case of TCR, and from -0.15 to 0.22 for Tier 1 ratio, when this binary variable takes the value of one.

Figure 4.4. Effects of a change in the Tier 1 capital ratio on net loans growth by bank size



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 11.68. Marginal effects are calculated based on coefficients drawn from Table B.1. in Annex.
Source: own elaboration.

The triple interaction between a capital ratio, the APP dummy, and the bank size category is not significant. Nonetheless, the marginal effect of capital ratios on lending growth is consistently higher for large banks than for smaller or medium-sized banks. The elasticity of bank loans growth with respect to a capital ratio for median levels of liquidity: (i) in Tier 1 regressions, rises from 0.11 for small banks to 0.47 for large banks; (ii) in TCR regressions, rises from 0.30 for small banks to 0.45 for large banks; and (iii) in ECR regressions, rises from -0.46 for small banks to -0.10 for large banks. This finding suggests that larger banks are in general (that is, also in the absence of the QE policy) more capital-constrained than the small ones, which makes large banks more responsive to shocks to capital. Thus, in particular lending of large banks can come to an abrupt halt once a negative shock occurs and hits their equity or capital ratio.

In summary, the activation of the QE policy has had a positive impact on the effect of bank capital ratios on bank lending for all banks grouped in three distinct size categories. However, the actual effect of capital on bank lending depends on bank liquidity level (see all three Figures 4.2., 4.3. and 4.4.). First of all, in this light the empirical Hypothesis 1 which states that the effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB shall be rejected. Thus far, according to the empirical evidence the identified impact of the QE policy on the studied link has been in general positive. Second, the empirical Hypothesis 2 which states the effect of bank capital ratios on bank lending is positively associated with the ECB's QE only for large banks with sufficient level of liquidity has to some extent been confirmed. Hence, as such it shall be rejected. The required adjustments to make it consistent with obtained evidence consist in modifying the second part of this hypothesis. Modifications includes the following results: (i) the positive impact of the QE is more pronounced in regressions where as an adopted measure of a capital ratio are regulatory binding risk-based ratios (as defined by the Basel Committee), that is the Tier 1 ratio and Total capital ratio; (ii) as in the primary interactive model, the QE effect diminishes as bank liquidity increases; and (iii) the highest positive QE effects are detected for small banks with low level of liquidity.

Based on the above insights and obtained results, I can address the Research questions 1 and 2. Firstly, the relationship between bank capital ratios and bank loans growth of European banks in the 2011-2018 period was indeed non-linear because in the linear-multiplicate models such as the ones described by Equations 4.2 and 4.4 several interactions terms that moderate this relationship were found significant. Thus, the obtained results once again support a positive answer to Research question 1. The studied relationship can be best described as non-linear. Secondly, as evidence from the interactive model shows, an answer to Research question 2 depends upon the definition of a capital ratio. In line with the previous baseline model's results, the marginal effects in the interactive models indicate that in the case of regulatory ratios (Tier 1 ratio and TCR) the relationship between bank capital ratios and bank loans growth was positive for sufficiently liquid banks in the period 2011-2018, whereas the said relationship in the case of asset-based equity capital ratio (ECR) was negative regardless of the level of bank liquidity[69].

In order to answer the Research question 3, I must enhance the interactive model represented by Equation 4.2 by adding a categorical variable for bank specialization. This

[69] For details on the sign of the studied relations for the general case, see Figure 4.1. See also Figure 4.2., Figure 4.3., and Figure 4.4. for marginal effects curves grouped by bank size.

operation can be, in fact, reduced to replacing a categorical variable bank size ($Size\_category_i$) in the regression specification 4.4 with a bank specialization category ($Specialization_i$). Performing said operation yields the following equation:

$$\begin{aligned} L_{i,t} = \beta_0 + \beta_1 L_{i,t-1} + \beta_2 CAP_{i,t-1} + \beta_3 LIQ_{i,t-1} + \beta_4 CAP_{i,t-1} \times LIQ_{i,t-1} \\ + \beta_5 CAP_{i,t-1} \times Specialization_i \\ + \beta_6 CAP_{i,t-1} \times APP_{d\,j,t} \times Specialization_i + \beta_7 CAP_{i,t-1} \times APP_{d\,j,t} \\ + \beta_8 CAP_{i,t-1} \times LIQ_{i,t-1} \times Specialization_i + \beta_9 LIQ_{i,t-1} \times APP_{d\,j,t} \\ + \beta_{10} CAP_{i,t-1} \times LIQ_{i,t-1} \times APP_{d\,j,t} + \sum_{l=1}^{k} \gamma_l X_{li,t-1} + \delta_1 \Delta GDP_{t-1} \\ + \varphi R_t + \delta_2 \Delta INT\_ST_{t-1} + \delta_3 CPI_{t-1} + \delta_4 MPI_{j,t-1} + \sum_{h=2011}^{2018} \theta_h Y_h \\ + \alpha_i + \varepsilon_{it} \end{aligned} \tag{4.5}$$

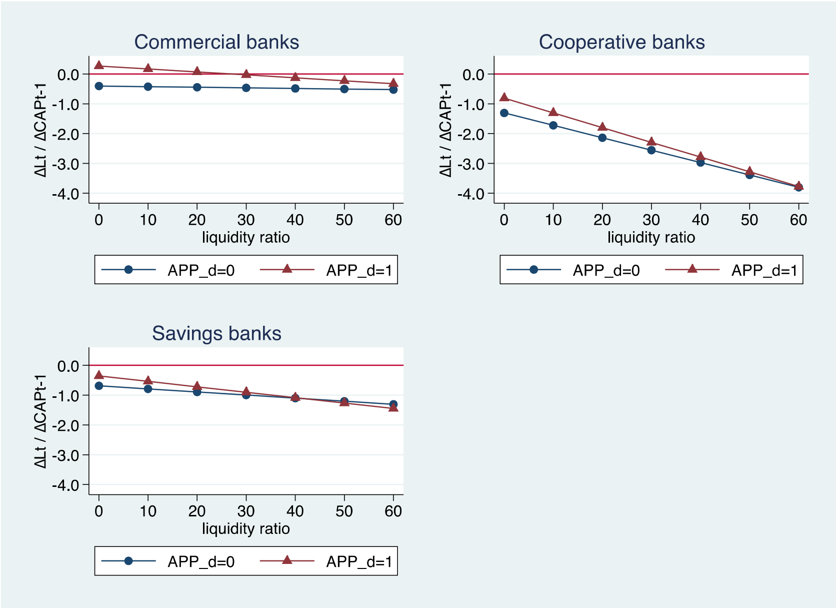
Where the notation is the same as in previous Equation 4.4. The bank specialization category ($Specialization_i$) takes the following values: 1 – for commercial banks (a reference category), 2 – for cooperative banks, and 3 – for savings banks. The estimation results for the interactive model described by Equation 4.5 are summarized in Table B.2. in Annex.

First, as in the previous case of the interactive model, the interactive specialization-enhanced model's coefficients associated with the liquidity ratio are all positive and significant. Second, in interaction-added regressions with regulatory ratios (columns 2 and 4 in Table B.2) the coefficients on an interaction between a capital ratio and the third category of Specialization variable ($\mathrm{CAP}_{t-1} \times Specialization[3]$) are highly significant and positive. This result suggests that savings banks are considerably less responsive to capital shocks to regulatory ratios than commercial banks. On the other hand, in the ECR interaction-added regression (column 6) a large and significantly negative coefficient on an interaction between a capital ratio and the second category of Specialization variable ($\mathrm{CAP}_{t-1} \times Specialization[2]$) points to high capital responsiveness of commercial banks compared to cooperative banks.

Figure 4.5 displays a conditional marginal effect of changes in ECR on bank loans growth for three categories of banks based on their specialization. As in previous models, marginal effects of capital in ECR regressions are negative for every bank specialization.

The marginal curves for commercial and savings bank are visibly flatter than the curve associated with cooperatives banks whose lending elasticity with respect to capital is declining rapidly with increases in the liquidity ratio (see Figure 4.5.).

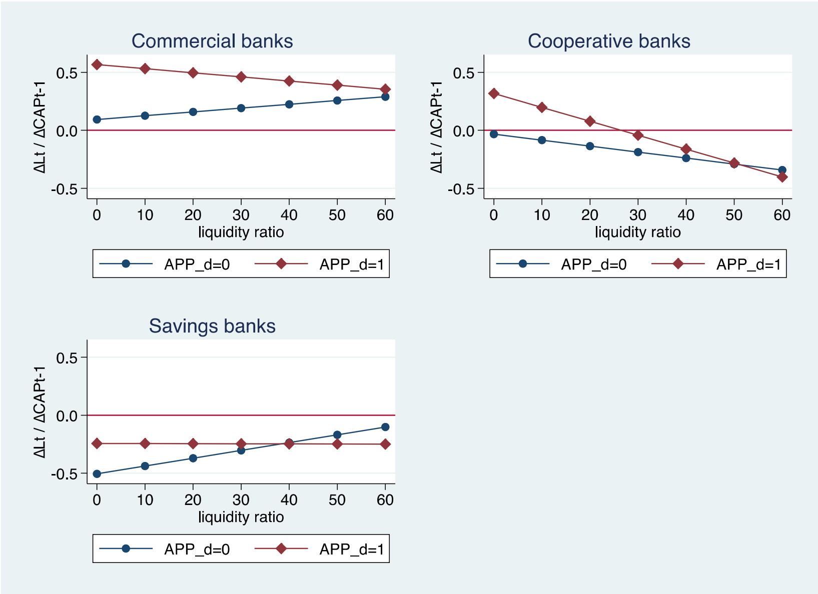
Figure 4.5. Effects of a change in equity capital ratio (ECR) on net loans growth by bank specialization



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 19.36. Marginal effects are calculated based on coefficients drawn from Table B.2. in Annex.
Source: own elaboration.

In the case of regulatory ratios, effects of changes in capital ratio on bank loans growth is also diverse, as it depends on a spectrum of factors, one of which is the impact of the QE policy. First, there is a sharp difference between commercial and savings banks. While the former tends to have a positive relationship between loans growth and capital ratio, the latter are characterized by a negative sign in the said relationship. Second, the QE policy is positively associated with capital effects on lending for banks of all specializations in case of less liquid banks and medium-liquid banks, except for commercial banks whose capital ratios exert a positive effect on bank lending growth even in the absence of the QE policy (see Figure 4.6. and Figure 4.7.). Third, for a median level of liquidity, the QE policy elevates the effect of capital on loans growth the most: (i) in Tier 1 regressions, from 0.02 to 0.59 for commercial banks; (ii) in TCR regressions, from 0.14 to 0.52 for commercial banks; and (iii) in ECR regressions, from -0.44 to 0.08 also for commercial banks[70].

Figure 4.6. Effects of a change in Total capital ratio (TCR) on net loans growth by bank specialization

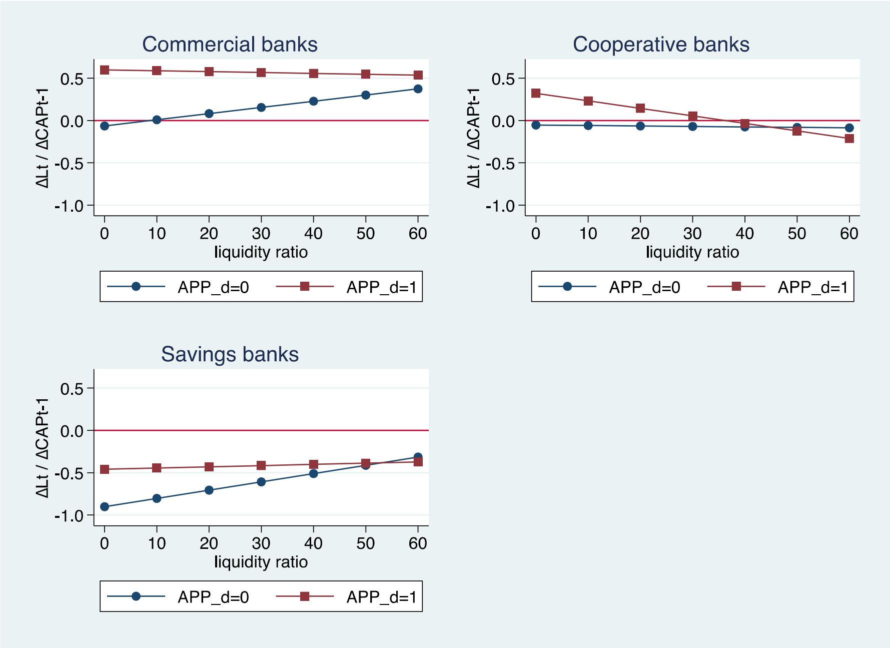


Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 13.40. Marginal effects are calculated based on coefficients drawn from Table B.2. in Annex.
Source: own elaboration.

In summary, it can be concluded that the impact of the QE policy has been significantly dependent on bank specialization in Europe, as it has strengthened the link between bank capital ratios and loans growth the most for European commercial banks[71]. Thus, this empirical evidence as well as the previous results allow me to answer positively to Research question 3 which states that the relationship between bank capital ratios and bank lending growth depended on a bank's size and specialization in the 2011-2018 period for European banks.

[70] The first number is the effect of a change in capital ratio on bank loans growth for banks not subjected to ECB's QE purchases under the APP, the second number relates to the same effect for banks subjected to such non-standard monetary policy. Therefore, it can be argued that it represents an impact of the QE policy.
[71] This empirical evidence is also confirmed by Figures 4.5., 4.6. and 4.7.

Figure 4.7. Effects of a change in the Tier 1 capital ratio on net loans growth by bank specialization



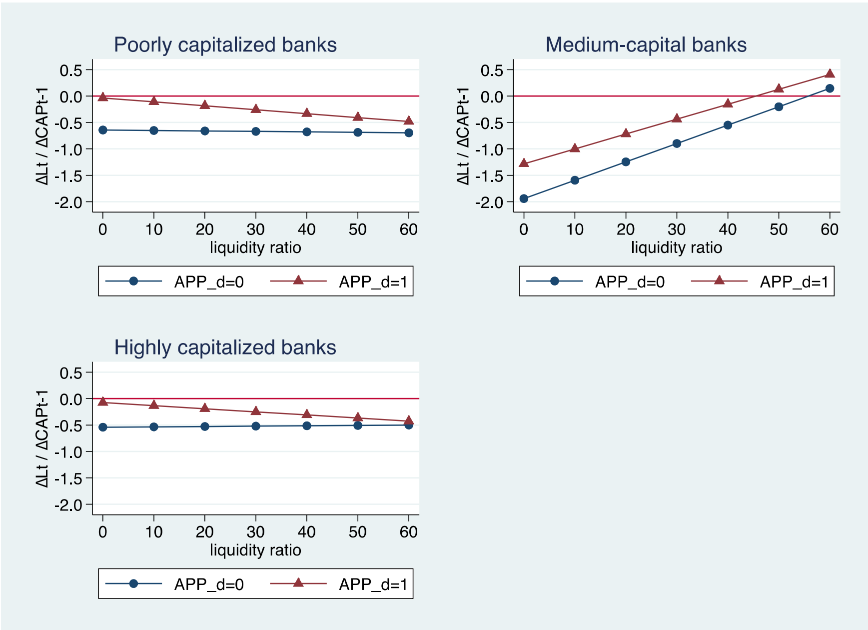
Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t}/\ \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 11.68. Marginal effects are calculated based on coefficients drawn from Table B.2. in Annex.
Source: own elaboration.

In order to answer Research question 4 and verify the empirical Hypothesis 3, it is crucial to rewrite Equation 4.5 once again, replacing the old categorical variable with a new categorical variable that represents a bank initial capital ratio ($Capital_i$). The bank capital category takes the following values: 1 – for poorly capitalized banks (a reference category), 2 – for medium-capital banks, and 3 – for well capitalized banks. The estimation results for the interactive model enhanced by the capital category are summarized in Table B.3. in Annex.

There are several observations to be made about the regressions output related to this capital category-enhanced interactive model. First, significant and negative coefficients on an interaction between regulatory capital ratios and the initial capital-to-asset ratio ($\mathrm{CAP}_{t-1} \times Capital[2]$ and $\mathrm{CAP}_{t-1} \times Capital[3]$ in columns 2 and 4 in Table B.3.) indicate that banks with initially low capital ratio (i.e., banks in a reference category) tend to be much more responsive to shocks to capital in their lending activities. This evidence is also supported by Figure 4.8. that depicts the marginal effect of ECR on bank loans growth for banks grouped in three distinct clusters based on their initial level of capitalization.

First of all, as in previous models the marginal effect of equity capital ratio (ECR) on bank lending are in general negative in contrast to analogous regressions with regulatory capital ratios (see Figure 4.8.). However, across all adopted measures of a capital ratio, banks with medium level of initial capitalization (whose average ECR in the 2011-2013 period was between 8% and 10%) are the ones most positively responsive to (and dependent on) the liquidity ratio. In fact, for all banks with sufficient level of liquidity the relationship between bank lending growth and capital ratios changes in sign after reaching a certain liquidity ratio threshold. The actual liquidity threshold is lowered for banks from countries subjected to the QE policy (see Figures 4.8., 4.9. and 4.10.).

Figure 4.8. Effects of a change in equity capital ratio (ECR) on net loans growth by bank capital category

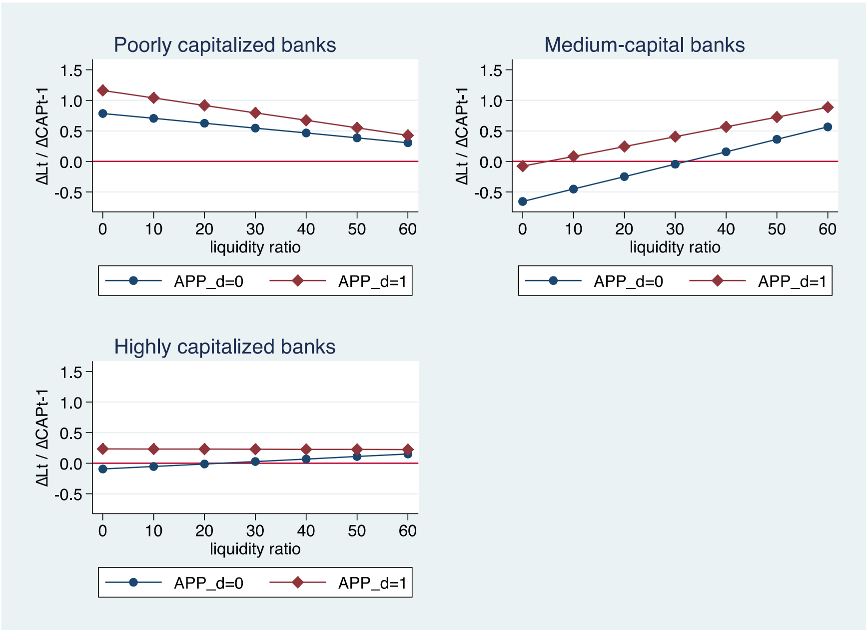


Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 18.57. Marginal effects are calculated based on coefficients drawn from Table B.3. in Annex.
Source: own elaboration.

Second, the QE policy is positively associated with capital effects on lending for banks in all three capital categories. However, the effect is somewhat larger for less liquid banks, in particular in the ECR and TCR regressions. Third, for a median level of liquidity, the QE policy increases the effect of capital on loans growth the most: (i) in

Tier 1 regressions, from -0.74 to 0.06 in the case of medium-capital banks; (ii) in TCR regressions, from -0.40 to 0.12 for medium-capital banks; and (iii) in ECR regressions, from -1.30 to -0.76 also for banks with medium level of initial capital. Fourthly, across all three capital ratios, the least responsive in their lending decisions to shocks to a capital ratio are well-capitalized banks. These banks with low level of initial capital are also to a less extent sensitive to the impact of the QE policy compared to two other groups of banks (see Figures 4.8., 4.9. and 4.10.).

Figure 4.9. Effects of a change in Total capital ratio (TCR) on net loans growth by bank capital category

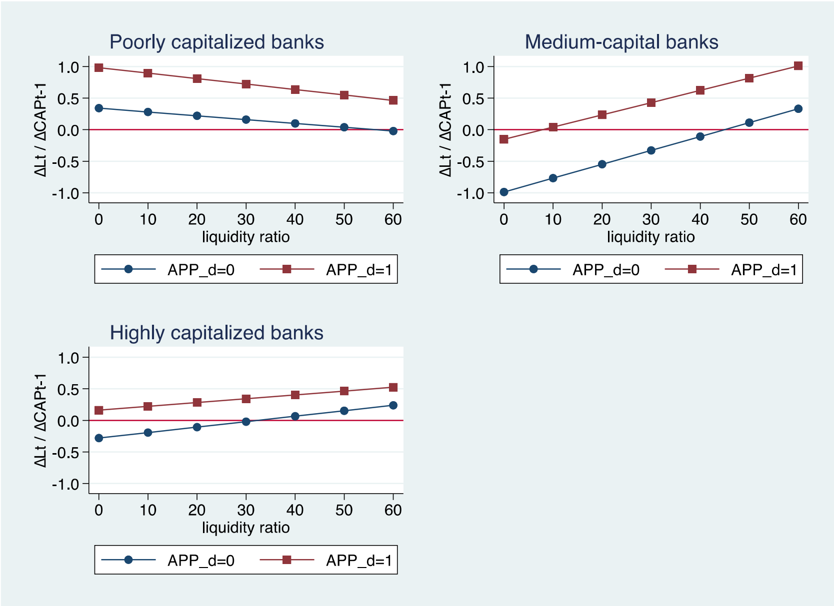


Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 12.40. Marginal effects are calculated based on coefficients drawn from Table B.3. in Annex.
Source: own elaboration.

In summary, the results obtained from the capital category-enhanced interactive model indicate an answer to Research question 4 and allow me to verify the empirical Hypothesis 3. First, Research question 4 stating that the relationship between bank capital ratios and bank lending growth depended on the bank's initial level of capitalization (that is, the initial capital-to-asset ratio) in the 2011-2018 period for European banks shall not be answered negatively. Therefore, the view that the bank's initial level of capitalization is important determinant of the impact of the QE policy on the studied link can be accepted. Banks with medium level of initial capital ratio are the most responsive to the

QE impact, whereas well-capitalized banks are the least responsive to this non-standard monetary policy. Of crucial importance in this mechanism is also the level of liquidity ratio, as described above.

Figure 4.10. Effects of a change in the Tier 1 capital ratio on net loans growth by bank capital category



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 11.07. Marginal effects are calculated based on coefficients drawn from Table B.3. in Annex.
Source: own elaboration.

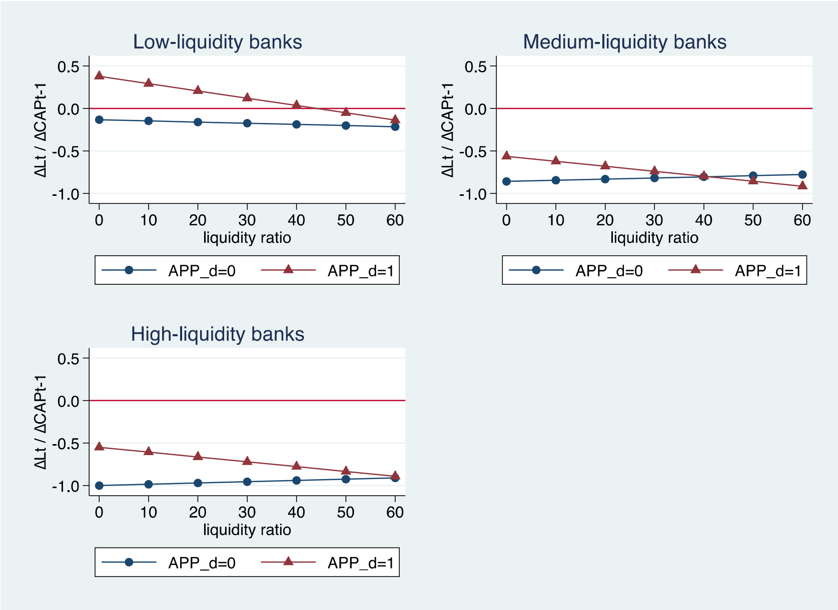
Second, Hypothesis 3 that states that the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for well-capitalized banks with sufficient level of liquidity is partly confirmed. Thus, as such it shall be rejected. The first part about the positive impact of the ECB's QE is confirmed by the empirical results from the capital category-enhanced interactive model. However, the second part needs some modifications. It can be restated in line with the obtained results as follows: the effect of bank capital ratios on bank lending is positively associated with the QE policy of the ECB for banks with various level of initial capital ratio and liquidity. Based on the empirical findings, modifications to the second part of Hypothesis 3 are as follows: (i) the positive impact of the QE is most pronounced for banks with medium level of initial capital ratio; (ii) as previously found in the case of interactive model, the QE effect diminishes as bank liquidity increases; and (iii) the least responsive in their lending to shocks to a capital ratio are well-capitalized banks, for which the positive impact of QE is also the most limited.

In order to answer Research question 5 and verify the empirical Hypothesis 3 from a different viewpoint, it is crucial to rewrite Equation 4.5 once again, replacing the bank specialization category with a categorical variable that represents a bank liquidity category ($Liquidity_i$). The bank liquidity category takes the following values: 1 – for high-liquidity banks (a reference category), 2 – for medium-liquidity banks, and 3 – for banks with low level of liquidity. The estimation results for the interactive model enhanced by the liquidity category are presented in Table B.4. in Annex.

First of all, coefficients on the interaction term between a capital ratio and liquidity category ($\mathrm{CAP}_{t-1} \times Liquidity[2]$ and $\mathrm{CAP}_{t-1} \times Liquidity[3]$) are mainly positive although not significant in all cases. This result would suggest that other variables may also moderate this relationship, including the QE dummy. However, the positive effect of liquidity on the link between bank capital and lending is likely to prevail, as previously estimated models have confirmed.

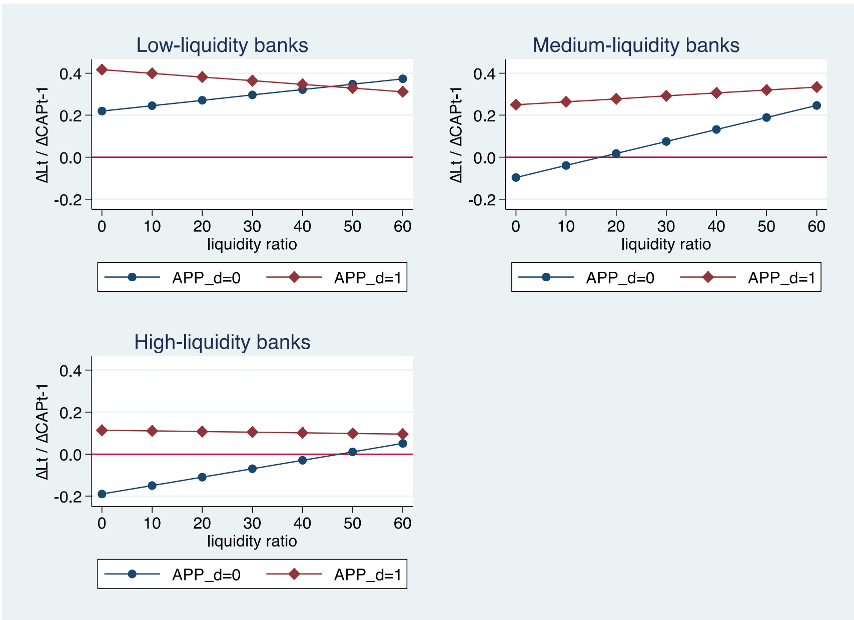
The empirical results for ECR regressions are in line with my prior expatiations. As Figure 4.11. indicates, the marginal effects curve with triangles is any case above the curve with circles, suggesting the overall positive impact of the QE policy on the studied link (see Figure 4.11.). In the case of medium- and high-liquidity banks regardless of the bank being subjected to the QE policy there exists a negative relationship between bank lending growth and the ECR. However, low-liquidity banks subjected to this unconventional monetary policy measure are characterized be positive sign in said relationship. In the case of less liquid banks, the impact of QE leads to a change of sign in the studied relationship between bank loans growth and the equity capital ratio (see the upper-left panel in Figure 4.11.).

Figure 4.11. Effects of a change in equity capital ratio (ECR) on net loans growth by bank liquidity category



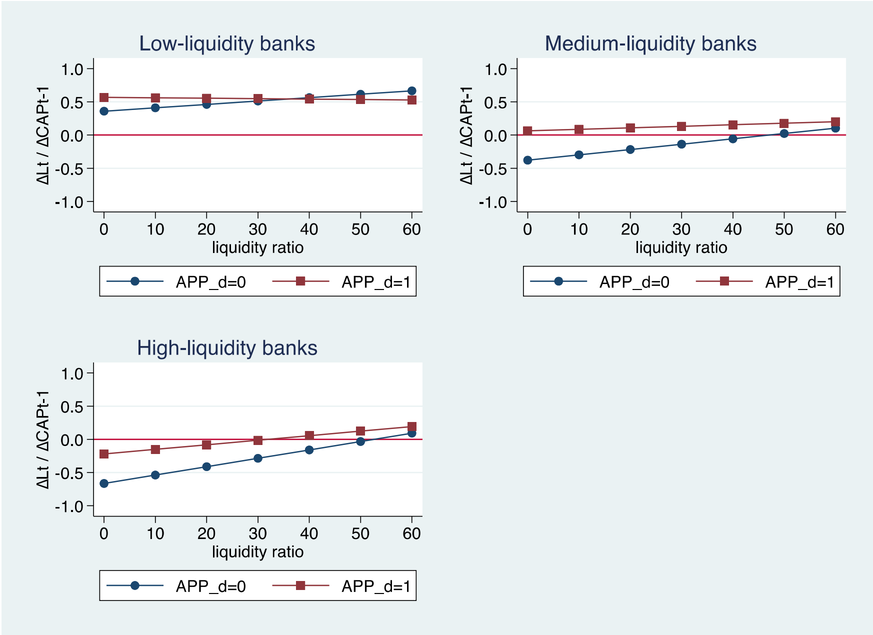
Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 19.36. Marginal effects are calculated based on coefficients drawn from Table B.4. in Annex.
Source: own elaboration.

Figure 4.12. Effects of a change in Total capital ratio (TCR) on net loans growth by bank liquidity category



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 13.40. Marginal effects are calculated based on coefficients drawn from Table B.4. in Annex.
Source: own elaboration.

Figure 4.13. Effects of a change in the Tier 1 capital ratio on net loans growth by bank liquidity category



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 11.68. Marginal effects are calculated based on coefficients drawn from Table B.4. in Annex.
Source: own elaboration.

In general, there are several observations worth noting. First, across all adopted measures of a capital ratio, for low- and medium-liquidity banks there exists a liquidity threshold above which the sign of a QE impact on the relationship between bank loans growth and a capital ratio changes from positive to negative. In ECR regressions, this liquidity threshold equals 40% and it holds for medium-liquidity banks (see the upper-right panel in Figure 4.11.). In TCR regressions, this liquidity threshold equals approximately 45% and it holds for low-liquidity banks (see the upper-left panel in Figure 4.12.). Lastly, in Tier 1 regressions, the liquidity threshold equals approximately 35% and it holds also for low-liquidity banks (see the upper-left panel in Figure 4.13.).

The above empirical results suggest that in the case of relatively illiquid banks the effect of bank capital ratios on bank lending is positively associated with the ECB's QE policy only until the point they retain a sufficient level of liquidity, after reaching that point the QE impact turns to be neutral or negative. On the other hand, in the case of highly liquid banks the QE effect is always positive but diminishes in magnitude as banks liquidity ratio increases (see lower-left panel in Figures 4.11., 4.12. and 4.13.). Thus, this evidence does not seem to support the empirical Hypothesis 3 in its full scope[72]. However, it does provide an unequivocal positive answer to Research question 5 because for European banks the relationship between bank capital ratios and bank lending indeed (crucially) depended on the bank's relative liquidity position expressed in its liquidity ratios in the 2011-2018 period. This bank-specific factor is undeniably a significant determinant of the QE impact on the link between loans growth and bank capital ratios.

4.2.2 Interactive model with country-specific factors

In this Section, in order to examine the last two empirical hypotheses, the interactive model is extended to include potential country-specific determinants of the growth of bank loans that could affect the QE policy impact on the relationship between capital ratios and bank lending growth.

The inclusion of categorical country-specific variables allows me to test the empirical Hypothesis 4 and Hypothesis 5 of the present thesis. The first specification involves factors that determine (i) a country's relative restrictiveness of capital adequacy standards and overall restrictions on banking activities; whereas the second specification focuses on factors shaping (ii) a country's financial market structure of the banking sector.

In order to examine Hypothesis 4, three country-specific factors are considered. In the first specification, a three-dimensional vector of country-specific categorical variables (a vector Z_{pj}) consisting of: (i) capital regulatory category (Cap_reg_j); (ii) restrictions on banking activities ($Act\_restrict_j$); and (iii) the official supervisory power (Sup_power_j)[73] is incorporated into the interactive model initially described by Equation 4.2. Thus, the first country-specific interaction-augmented regression specification is as follows:

[72] Based on the capital category-enhanced interactive model, the previously proposed modifications to the empirical Hypothesis 3 still apply.

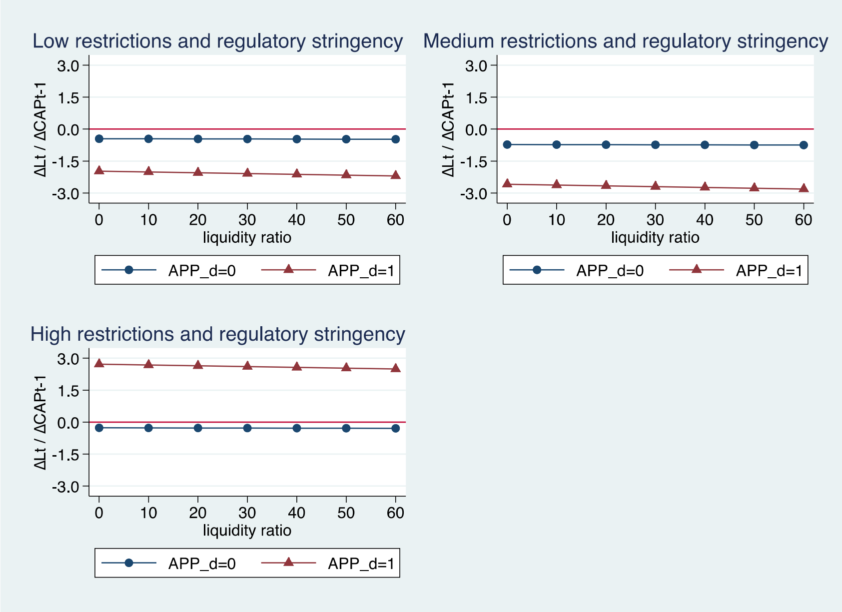
[73] For details on how these categorical variables are constructed, see Table 3.1 in Chapter 3.

$$
\begin{aligned}
L_{i,t} = \beta_0 + \beta_1 L_{i,t-1} + \beta_2 CAP_{i,t-1} + \beta_3 LIQ_{i,t-1} + \beta_4 CAP_{i,t-1} \times LIQ_{i,t-1} \\
+ \beta_5 CAP_{i,t-1} \times APP_{d\,j,t} + \beta_6 LIQ_{i,t-1} \times APP_{d\,j,t} \\
+ \beta_7 CAP_{i,t-1} \times LIQ_{i,t-1} \times APP_{d\,j,t} \\
+ \sum_{p=1}^{3} \left(\mu_p CAP_{i,t-1} \times Z_{pj} + \nu_p CAP_{i,t-1} \times Z_{pj} \times APP_{d\,j,t} \right) \\
+ \sum_{l=1}^{k} \gamma_l X_{li,t-1} + \delta_1 \Delta GDP_{t-1} + \varphi R_t + \delta_2 \Delta INT\_ST_{t-1} + \delta_3 CPI_{t-1} \\
+ \delta_4 MPI_{j,t-1} + \sum_{h=2011}^{2018} \theta_h Y_h + \alpha_i + \varepsilon_{it}
\end{aligned}
\tag{4.6}
$$

where *i* refers to the individual bank, *t* denotes the time dimension and *j* is a country subscript. Sign notation of other variables and indexes is the same as in Equations 4.1 and 4.2. The panel fixed-effects estimates of coefficients and statistics associated with Equation 4.6 are presented in Table C.1. in Annex.

As Figure 4.14. illustrates, the effect of changes in the equity capital ratio on bank lending growth is negative for low and medium-level of capital regulatory and other restrictions that European banks face in different countries. The relationship between bank loans growth and the ECR is negatively associated with the ECB's QE policy for banks from countries with less stringent restrictions on banking activities for all levels of bank liquidity (see upper panels in Figure 4.14.). However, in the case of banks facing more restrict capital regulations and high restrictions on banking activities and more restrictive domestic capital regulations, the QE effect on investigated relationship is significantly positive regardless of the level of bank liquidity ratio (see the lower panel in Figure 4.14.).

Figure 4.14. Effects of a change in equity capital ratio (ECR) on net loans growth by country-specific bank activity regulatory variables



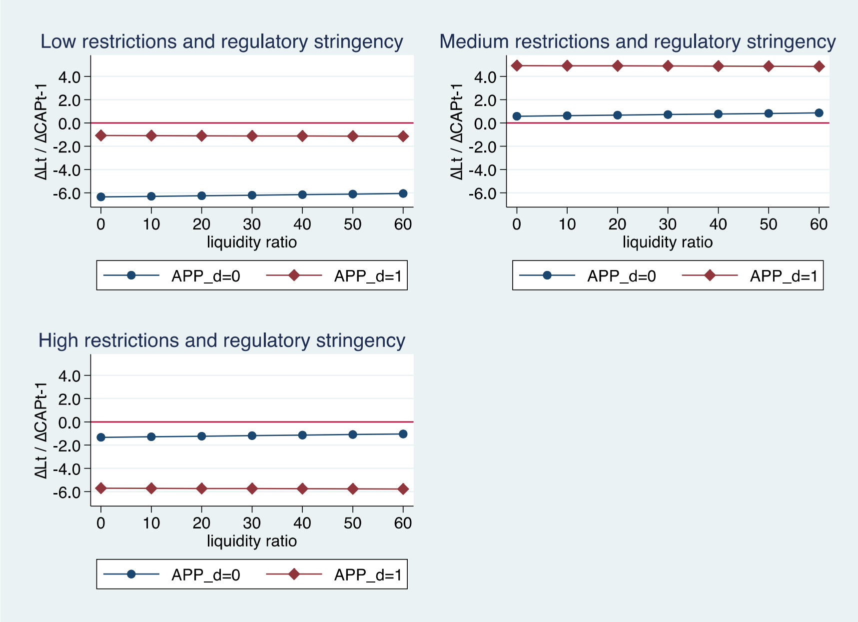
Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 26.88. Marginal effects are calculated based on coefficients drawn from Table C.1. in Annex.
Source: own elaboration.

Table C.1. indicates that an interaction term between capital ratios and the QE binary variable ($\mathrm{CAP}_{t-1} \times APP\_d$) is significant and negative in the case of ECR and significantly positive for regulatory capital ratios. On the other hand, an interaction term between capital ratios and bank liquidity ($\mathrm{CAP}_{t-1} \times \mathrm{LIQ}_{t-1}$) is positive and significant at the 10 percent significance level only in regressions with Tier 1 capital ratio and TCR as a capital ratio. The empirical results show that in most regressions, there exists a significant impact of interactions with country-specific level of capital regulatory restrictions and other restrictions on banking activities, and with stringency of financial supervision.

In all cases, the effect of medium and high restrictions on banking activities ($Act\_restrict_j$) on studied relationship is positive and highly significant. This positive effect is intuitively valid, as it means that banks from countries with more restrictions on banking activities, including capital regulatory requirements, are more responsive (and thus constrained) in their lending to changes in the level of their capital ratios[74].

[74] For specific numbers, see coefficients on the interaction term $\mathrm{CAP}_{t-1} \times$ Act_restrict in Table C.1.

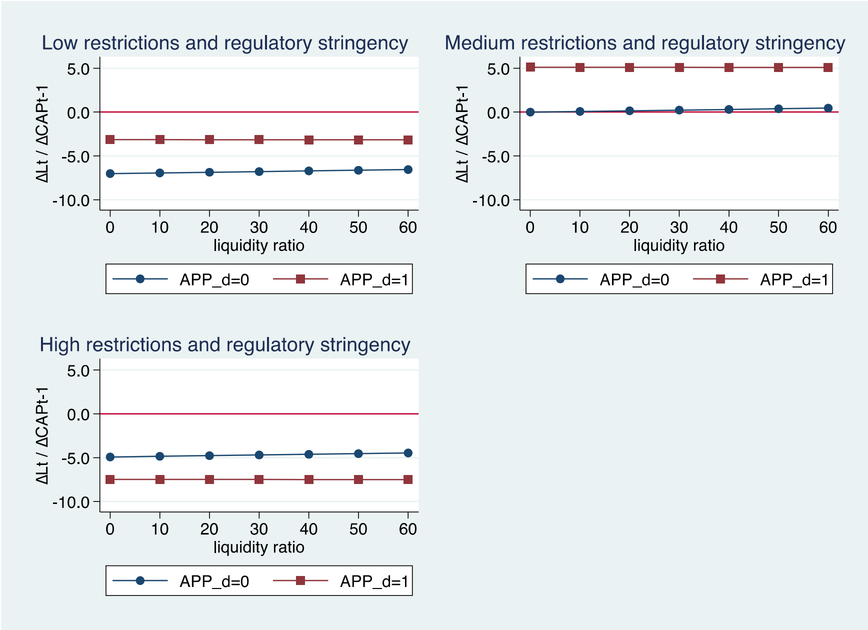
Figure 4.15. Effects of a change in Total capital ratio (TCR) on net loans growth by bank activity regulatory variables



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 22.09. Marginal effects are calculated based on coefficients drawn from Table C.1. in Annex.
Source: own elaboration.

There is a number of empirical findings related to regressions with regulatory definition of a capital ratio. Firstly, while the positive effect of higher restrictions on banking activity seems to hold across all adopted measures of a capital ratio, the impact of QE is essentially different when it comes to regulatory bank capital ratios. In contrast to the results obtained for ECR regressions, QE effects are significantly positive for banks from countries with low and medium-level of capital regulatory and other restrictions on banking activities (see upper panels in Figure 4.15. and Figure 4.16.). Secondly, the empirical results support Hypothesis 4 because they show that in the case of regulatory capital ratios the effect of bank capital ratios on bank lending is negatively associated with the QE policy of the ECB for banks from countries characterized by more restrictive capital regulations and more stringent overall restrictions on banking activities (see the bottom panel in Figure 4.15. and Figure 4.16.). Thirdly, the QE effects do not diminish as bank liquidity ratio increases. This last observation would suggest that the country-specific determinant in the form of a degree of restrictions imposed on banks could be an overriding condition and a more binding constraint for bank lending in Europe than bank-specific factors such as liquidity ratio.

Figure 4.16. Effects of a change in the Tier 1 capital ratio on net loans growth by bank activity regulatory variables



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 17.78. Marginal effects are calculated based on coefficients drawn from Table C.1. in Annex.
Source: own elaboration.

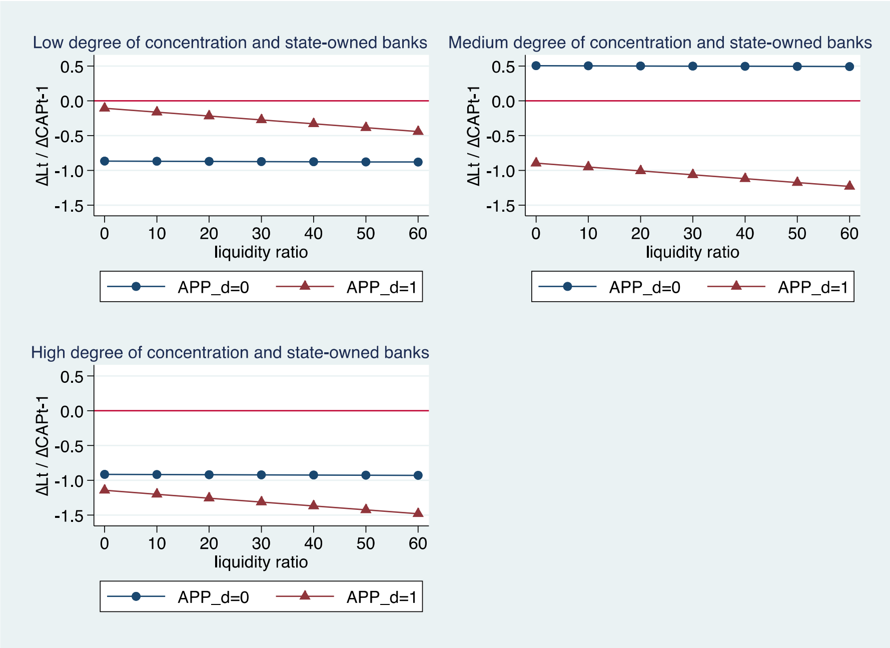
The second empirical specification that involves country-specific determinants that could affect the QE policy impact on the relationship between capital ratios and bank lending growth revolves around factors shaping a country's financial market structure of the banking sector. Thus, in order to examine the last empirical Hypothesis 5, two country-specific variables are considered. In this specification, a two-dimensional vector of country-specific categorical variables (a vector C_{pj}) consisting of: (i) a banking sector's market concentration measure ($Bank\_conc_j$); and (ii) a variable that indicates the extent to which the banking system's assets are owned by the government (Gov_banks_j) is incorporated into the interactive model described before by Equation 4.2. The second country-specific interaction-augmented regression specification therefore reads as follows:

$$
\begin{aligned}
L_{i,t} = \beta_0 + \beta_1 L_{i,t-1} + \beta_2 CAP_{i,t-1} + \beta_3 LIQ_{i,t-1} + \beta_4 CAP_{i,t-1} \times LIQ_{i,t-1} \\
+ \beta_5 CAP_{i,t-1} \times APP_{d\,j,t} + \beta_6 LIQ_{i,t-1} \times APP_{d\,j,t} \\
+ \beta_7 CAP_{i,t-1} \times LIQ_{i,t-1} \times APP_{d\,j,t} \\
+ \sum_{p=1}^{2} \left(\mu_p CAP_{i,t-1} \times C_{pj} + \nu_p CAP_{i,t-1} \times C_{pj} \times APP_{d\,j,t} \right) \\
+ \sum_{l=1}^{k} \gamma_l X_{li,t-1} + \delta_1 \Delta GDP_{t-1} + \varphi R_t + \delta_2 \Delta INT\_ST_{t-1} + \delta_3 CPI_{t-1} \\
+ \delta_4 MPI_{j,t-1} + \sum_{h=2011}^{2018} \theta_h Y_h + \alpha_i + \varepsilon_{it}
\end{aligned}
\tag{4.7}
$$

where *i* refers to an individual bank, *t* is the time dimension and *j* is a country subscript. Other sign notation is the same as in Equations 4.1 and 4.2. The fixed-effects estimates of coefficients and related statistics associated with Equation 4.7 are summarized in Table C.2. in Annex.

As Table C.2. presents, coefficients on the interaction term between a capital ratio and banking market concentration category ($CAP_{t-1} \times Bank\_conc$) are in the majority of cases significantly positive, indicating that banks from countries with medium and high degree of market concentration (and hence with more market power) are more responsive to capital ratios in their lending activities. In particular, in these countries banks seems to be the most responsive and the most constrained by the Tier 1 capital ratio (see Figure 4.19.). However, in the case of equity capital ratio and Total capital ratio banks operating in highly concentrated market with large degree of state-owned banks are characterized by a negative relationship between bank loans growth and a capital ratio (see the bottom panel in Figure 4.17. and Figure 4.18.).

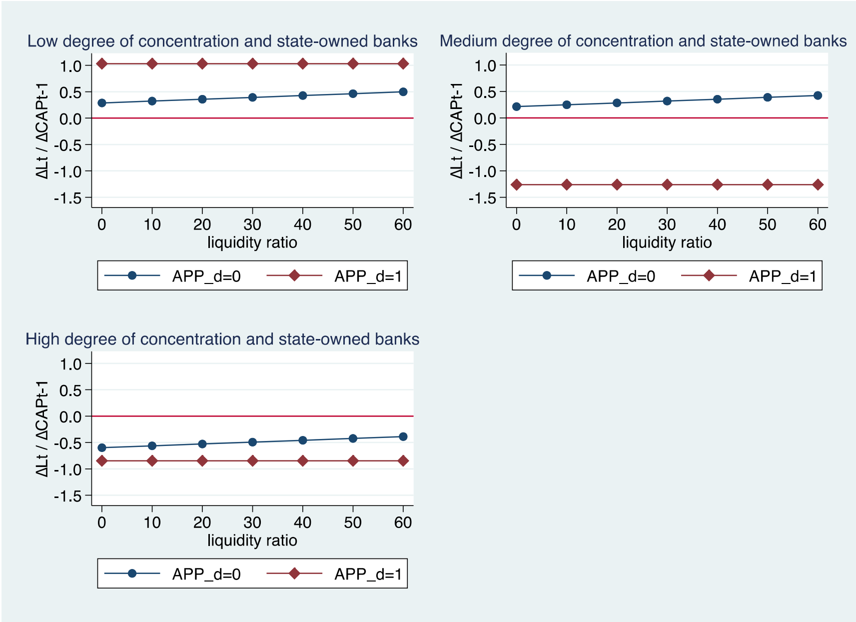
Figure 4.17. Effects of a change in equity capital ratio (ECR) on net loans growth by banking market structure characteristics



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 19.53. Marginal effects are calculated based on coefficients drawn from Table C.2. in Annex.
Source: own elaboration.

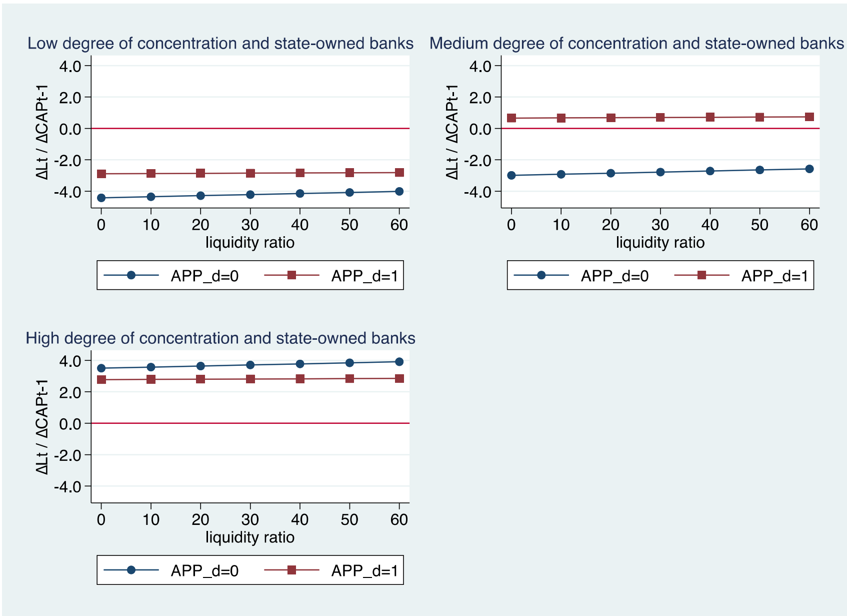
The QE effect on the relationship between bank lending growth and capital ratio is positive across all adopted definition of a capital ratio only for banks from banking systems characterized by a low degree of market concentration and a low extent of government-owned banks (see Figure 4.17., Figure 4.18. and Figure 4.19.). The only exception is the Tier1 regressions where a positive effect of the QE policy is also found for banks from countries with medium degree of a banking sector concentration and medium extent of banks owned by the government. Thus, according to the obtained empirical results, Hypothesis 5 shall be rejected. In line with the empirical evidence, Hypothesis 5 should be restated as follows. The effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for banks from countries with a small concentration of the banking sector and with a low share of state-owned banks. Lastly, it is interesting to note that in all regressions for the medium degree of market concentration and state-owned banks in the banking sector the impact of QE is to change a sign in the relationship between bank lending growth and a capital ratio. In the case of ECR and TCR, the QE shifts the sign from positive to negative territory and does conversely in the case of Tier1.

Figure 4.18. Effects of a change in Total capital ratio (TCR) on net loans growth by banking market structure characteristics



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 13.24. Marginal effects are calculated based on coefficients drawn from Table C.2. in Annex.
Source: own elaboration.

Figure 4.19. Effects of a change in the Tier 1 capital ratio on net loans growth by banking market structure characteristics



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. A median level of liquidity ratio equals 11.55. Marginal effects are calculated based on coefficients drawn from Table C.2. in Annex.
Source: own elaboration.

4.3 Robustness checks

As a first check of robustness of the results, I compare and check whether empirical findings are robust to using alternative sample of data, namely institution-level data reported in consolidated bank annual statements. Because consolidated data is mostly available for large banks and commercial banks[75]. I will analyze the baseline and interactive results obtained for these two groups.

Table D.1 in Annex reports results for the baseline model (described by Equation 4.1) estimated on unconsolidated and consolidated data, whereas Table D.2. presents the analogous results estimated on both samples for the interactive model (identified by Equation 4.2). In both tables, Panel A shows regressions with net loans (growth of logarithm) as a dependent variable and Panel B presents net loans growth rate as dependent variable. In the baseline specification, coefficients on lagged dependent variables are all negative and mostly insignificant in both cases. In addition, coefficients on capital ratios are all positive across all columns 1-3 (consolidated data) and columns 4-6 (unconsolidated data). Other coefficients associated with macroeconomic variables are for the most part consistent in two samples.

As shown in Table D.2., added interaction terms are statistically significant only in the ECR regression on unconsolidated data for large banks (column 6). This result may suggest that the QE policy in a sample of large banks both on consolidated and unconsolidated data is not a significant determinant of effects of a bank capital ratio on bank loan growth. Nonetheless, as other results are largely consistent in both the case of consolidated and unconsolidated data, the results may be said to be stable and robust. However, to further examine this issue it is worth analyzing the analogous results for commercial banks.

Table D.3. and Table D.4. in Annex report results obtained for commercial banks according to the baseline model and interactive model, respectively and estimated on both consolidated and unconsolidated data. In the case of baseline regression, the estimates are consistent and similar both when estimated on consolidated data (columns 1-3 in Table D.3.) and when estimated on unconsolidated data (columns 4-6). Moreover, insignificant

[75] Consolidated data on large banks (2,050 obs.) constitutes 71.55% of total observations on all sizes of banks (2,865 obs.) in the adjusted (final) sample. Whereas consolidated data on commercial banks (1,711 obs.) accounts for 59.72% of total observations on all types of banks (2,865 obs.) in the adjusted (final) sample.

and positive coefficients on the lagged net loan growth (L_{t-1}) as well as the negative coefficient on the lagged ECR both in the case of consolidated (column 3) and unconsolidated data (column 6) indicate that these results are robust and consistent with the baseline results obtained for the full sample of unconsolidated data presented in Table 4.2. in Section 4.1. On average, higher R-squared statistics and strong statistical significance of key variables and interactive terms in the case of regressions on unconsolidated data points to the likelihood that both the baseline and interactive model fit better to this type of panel data and that the choice of using unconsolidated data across the empirical part of the thesis is justified[76].

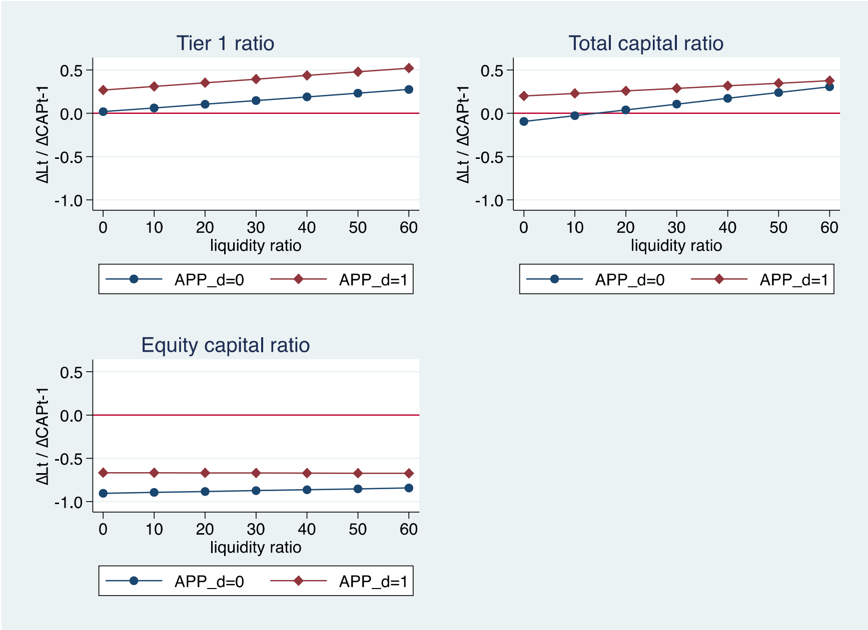
The second check of robustness of the results consists in using an alternative measure of bank liquidity ratio. In all previous regressions, liquid assets to customer deposits and short-term funding ratio (LADSTF) has been adopted as a measure of bank liquidity. In order to check if the results are robust to a change in this dimension, I replace it with the liquid assets to deposits and borrowing ratio (LATDB) in the interactive model's specification (see the results of this exercise in Table D.5. in Annex). The expected effect of this measure of bank liquidity is the same as was argued in Table 4.1. in Section 4.1. That is, banks that have more liquid assets on their balance sheets in relation to their short-term liabilities are exposed to less liquidity risk and thus in theory can supply more loans. The robustness check will be performed on the Figure 4.1. related to the first interactive model (identified by Equation 4.2). To remind, it shows the elasticity of bank net loans growth with respect to bank capital ratios.

Across all three capital ratios, the positive effect of the QE policy on the link between bank capital ratio and bank loan growth is clearly visible in Figure 4.20. It is essentially the same effect as in the analogous Figure 4.1. created with a previous measure of bank liquidity. In addition, all the estimates of coefficients for both regressions are indeed consistent and very similar. This observation is confirmed by Table D.5 in Annex that juxtaposes estimates for these two variants. That is, Panel A (columns 1-3) shows regression results for the alternative liquidity ratio (i.e., LATDB) and Panel B (columns 4-6) presents results for previously employed measure of bank liquidity (i.e., LADSTF). A visual comparison of Figure 4.1. and Figure 4.20. supports the notion that in the case of regressions with LATDB, the QE effects on studied link do not diminish as bank

[76] Estimates reported in Table D.4. in Annex are also in line with this statement.

liquidity increases, as was the case in regressions with LADSTF adopted as a liquidity ratio measure (cf. Figure 4.1.).

Figure 4.20. Robustness check of elasticity of bank net loans growth with respect to bank capital ratios with an alternative measure of liquidity ratio



Notes: This graph is based on the final sample of unconsolidated data. Vertical axis represents a partial derivative of net loans (growth of logarithm) with respect to a lagged capital ratio, that is $\partial L_{i,t} / \partial CAP_{i,t-1}$. Liquidity ratio is defined as liquid assets to deposits and borrowing ratio (LATDB). A median level of liquidity ratio equals 10.44, 11.48 and 15.91 in the case of the regression with Tier 1 ratio, TCR and ECR, respectively, as a capital ratio. Marginal effects of key capital ratios are calculated based on coefficients drawn from Table D.5.
Source: own elaboration.

Quantitative results of this robustness check exercise are as follows. For a median level of bank liquidity, the QE policy elevates the effect of 1-percentage-point increase in a capital ratio on the bank loans growth by approximately: (i) in the case of ECR: 0.28 percentage points for LADSTF and 0.22 percentage points for the alternative LATDB; (ii) in the case of TCR: 0.27 percentage points for LADSTF and 0.25 percentage points for LATDB; and (iii) in the regression with Tier 1 ratio: 0.37 percentage points for LADSTF and 0.25 percentage points for LATDB. The results of the robustness check thus show that in the case of ECR the difference equals approximately 6 basis points, for the TCR only 2 basis points, and in the case of Tier 1 ratio approximately 12 basis points. These relatively small differences and consistent and very similar estimates in both panels of Table D.5. point to the strong probability that previously obtained results are indeed stable and robust.

It is important to note that throughout the empirical part of the present dissertation the applied method has accounted for ensuring the robustness of final results and conclusions. Importantly, in both baseline and interactive models in Section 4.1 and Section 4.2 two distinct dependent variables were checked (see Table 4.2. and Table 4.4.). Moreover, in the majority of estimated regressions three distinct measures of capital ratio has been adopted. The results are thus for a large part checked for robustness to different initial settings and specifications.

4.4 Discussion of research findings

In relation to the 1990-1991 recession Van den Heuvel (2002) stressed that research on this and other episodes of the capital crunch had found that "low bank capital is associated with sluggish lending" (Van den Heuvel, 2002, p. 259). This statement can be viewed as an early recognition of the notion of a positive relationship between the bank lending (growth) and bank capital (ratios). This observation is in line with the 'risk absorption' hypothesis put forward by Berger & Bouwman (2009) in the aftermath of the Global Financial Crisis (GFC) and the ensuing period of the Great Recession of 2007-2009. In fact, many post-crisis empirical studies, in particular Berrospide & Edge (2010); Carlson et al. (2013); Kim & Sohn (2017); Mora & Logan (2012); Olszak et al. (2017) and (2016) have supported the view of the positive relationship existing between bank lending growth and bank capital (adequacy) ratios. Importantly, this 'risk absorption' view contradicts the alternative 'financial fragility-crowding out' hypothesis (Berger & Bouwman, 2009). In addition, according to many reviewed empirical studies this relationship is rather complicated and in its essence is non-linear (Beatty & Liao, 2011; Brei et al., 2013; Carlson et al., 2013; Casu et al., 2018; Kim & Sohn, 2017; Olszak et al., 2016).

The empirical results of the present dissertation confirm most of the findings of the reviewed strands of the literature. With regard to five research questions stated in the introduction and Chapter 1, the present study has answered them positively for the most part. That is, all research questions have received a positive answer, except for Research question 2 which receives a conditional answer.

Firstly, based on the results from the baseline model estimated using the robust fixed effects estimator on annual bank panel data spanning the 2011-2018 period, it confirms that the relationship between bank capital ratios and bank loans growth for European banks in the 2011-2018 period was indeed non-linear. Two pieces of evidence points to such a conclusion. First, regulatory capital requirements such as Tier 1 ratio and Total capital ratio exert a significantly positive effect on bank lending, while the equity capital ratio affects the net loans growth negatively. Second, empirical results from the interactive models with bank-specific and analogous models with country-specific variables confirmed the significance of many factors that moderate this relationship along with the Quantitative Easing policy of the European Central Bank (ECB).

Secondly, the interactive model shows that the sign of studied relationship crucially depends upon the definition of a capital ratio. This finding may be a significant contribution to the literature. Consistent with the results of a study by Thornton & Tommaso (2020), but in contrast to the findings of Roulet (2018), estimated marginal effects in the interactive models indicate that in the case of regulatory ratios (Tier 1 ratio and Total capital ratio) the relationship between bank capital ratios and bank loans growth was positive for sufficiently liquid banks in the period 2011-2018. However, said relationship in the case of equity capital ratio was negative regardless of the level of bank liquidity.

Thirdly, obtained empirical evidence confirms previous findings of studies reviewed in Chapter 1. Crucially, the results show that the relationship between bank capital ratios and bank loans growth in the 2011-2018 period in the case of banks in Europe significantly depended on a range of bank-specific characteristics, such as: (i) bank's size and specialization; (ii) bank's initial level of capitalization; and (iii) relative liquidity position.

In relation to empirical hypothesis, the research findings of the present thesis point to some important monetary policy considerations and implications.

Since the publication of an empirical study by Kishan & Opiela (2006), who found evidence for two important sources of asymmetry in the monetary policy transmission mechanism, that is the policy-stance asymmetry and cross-sectional asymmetry, the issue of bank capital constraints has been an important consideration for monetary policy researchers and policymakers. Unconventional monetary policy measures, and in particular the QE policy adopted by major central banks after the outburst of GFC in 2008 have been found to significantly interact with the distribution of bank liquidity and capital in the banking sector (Horst & Neyer, 2019; Ryan & Whelan, 2021).

The issue of determinants of the impact of quantitative easing policy of the ECB on the link between bank loans growth and capital ratios has been scarcely covered in the literature, leaving a research gap that the present thesis wishes to fill.

Following the analysis and conclusions of Demertzis & Wolff (2016) and Horst & Neyer (2019) who argued about reduced profitability and balance sheet costs of QE brought about as side-effects of the ECB' QE policy, that is Asset Purchase Program (APP), the present study hypothesizes that the effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB (that is, Hypothesis 1). This hypothesis is also in line with recent findings of Ryan & Whelan (2021) who provided evidence that banks from the euro are have been exposed to disincentives to hold excess reserves because of the ECB's policy of negative interest rate on its deposit facility, and "thus could wish to treat them as a 'hot potato' that is preferably passed on to other banks" (Ryan & Whelan, 2021, p. 1). In this light, the side-effect (balance sheet) costs of the QE policy could outweigh any potential liquidity benefits for banks as found to exist in studies by Kim & Sohn (2017) for the US and by Thornton & Tommaso (2020) in the European context.

However, the results from the empirical fixed-effect interactive model, described by Equation 4.2, do not support this Hypothesis 1. On the contrary, according to the obtained evidence, the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB. This finding holds for all three used measures of bank capital adequacy ratio. It is robust to using an alternative liquidity ratio. As a result, the finding can be viewed as another important contribution of the present thesis.

In addition, the interactive model with the bank size interacting with QE policy and capital ratios (described by Equation 4.4) shows that the identified positive and significant impact of the QE policy on the studied link declines as the liquidity ratio increases. This evidence is also confirmed by the robustness check exercise with an alternative measure of bank liquidity ratio. Thus, the obtained results support conclusions reached by Kim & Sohn (2017) and Thornton & Tommaso (2020) who reported that "the effect of an increase in bank capital is positively associated with the level of bank liquidity" (Thornton & Tommaso, 2020, p. 1) if the activation of the QE policy is viewed as a bank 'liquidity improving tool'.

The above conclusion is to some extent similar to Hypothesis 2 which in turn has been partly confirmed in the present thesis. It states that the effect of bank capital ratios on bank lending is positively associated with the ECB's QE only for large banks with sufficient level of liquidity. Although the results confirm a positive impact of QE supporting the first part of Hypothesis 2, the second part needs some modifications and conditionality. According to the interactive model with the interaction between bank size, QE policy and capital ratios (described by Equation 4.4), the positive effect of QE on the studied link is most pronounced for small banks with low level of liquidity. Additionally, this effect is only detected in regressions where as an adopted measure of a capital ratio are regulatory risk-based capital ratios, namely Tier 1 ratio and TCR.

The results from the capital-enhanced interactive model indicate that Hypothesis 3 which states that the effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for well-capitalized and sufficiently liquid banks can only be partly confirmed. First, results suggest that the positive impact of the QE is most pronounced for banks with medium level of initial capital ratio. Second, the positive effect of the QE diminishes as bank liquidity increases. Intuitively, the results also show that the least responsive in their lending activity to shocks to relative capital position are well-capitalized banks.

In line with an early study of Ehrmann, Gambacorta, Martínez-Pagés, Sevestre, & Worms (2001) and post-crisis studies such as, for example Horst & Neyer (2019) and Ryan & Whelan, (2021), the last part of the empirical part of the thesis takes account of the country-specific factors and large heterogeneity across the European banking systems. This part yields two major conclusions. Firstly, consistently with Roulet (2018), the results confirm Hypothesis 4 that the effect of bank capital ratios on bank lending is negatively associated with the ECB's QE policy only for banks from countries characterized by more restrictive capital regulations and relatively more stringent restrictions on banking activities. Secondly, results tend to suggest that Hypothesis 5 should not be accepted. Contrary to the postulated view consistent with 'Too Big To Fail' theory (see Kim & Sohn, 2017, p. 100; Marshall & Rochon, 2019, p. 61), the empirical interactive model enhanced by interactions between country-specific factors, and described by Equation 4.7, shows that effects of bank capital ratios on bank lending is positively associated with the QE policy only for banks from countries with a small concentration of the banking sector and with a low share of state-owned banks.

Lastly, it is important to point out some limitations of the conducted empirical research. First, due to data frequency and availability the identified 'QE impact' is rather generally matched with specific European banks subjected to this unconventional policy because the adopted APP dummy indicates a country of risk (that is, the issuer's country), namely a country of the issuer of a specific financial instrument or debt security purchased under the APP program[77]. In other words, the lack of explicit information of direct counterparties to the ECB's APP purchases contributes to this issue. Second, in order to check the impulse response functions (IRFs) related to unconventional monetary policy shocks that could inform about the QE effects on the studied link over time, the panel VAR model could be estimated as an additional empirical method of the research. However, a relatively short time period of the current study excludes this possibility. This data limitation also did not allow me to run the standard stationarity (unit-root) tests such as the augmented Dickey–Fuller test (ADF). In this case, spurious regressions were omitted by estimating models on first differences (growth rates) of logarithm of variables if possible.

A final identified study limitation concerns using a binary variable (the APP dummy) as a proxy for the QE policy. This variable indicates two dimensions: years of the active functioning of all parts of the ECB's APP program, and banks from countries of risk. Instead, all four subprograms of the ECB's Asset Purchase Program could be considered as a QE proxy to account for changes and the pace of adjustments in the targeted quantities of purchases under such subprograms[78]. It remains as one of potential directions for future research.

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[77] Out of total 54 countries present in the full sample of this study, only 19 countries from the euro area were potential subjects of the APP purchases examined in this study. Therefore, only issuers from these countries were considered as a potential country of risk.
[78] The ECB's APP subprograms include ABSPP, PSPP, CBPP3 and CSPP. For more details of each, see Table 3.1 in Chapter 3 of the present thesis.

Conclusions

This thesis focused on determinants and consequences for the link between bank lending and capital ratios of the quantitative easing policy initiated by the European Central Bank in Europe under the Asset Purchase Program[79] in 2014. The primary objective of the thesis was to examine factors that determine the QE policy impact on the relationship between the bank lending activities and bank capital ratios for European banks. This objective has been achieved.

Overall, the results indicate that ECB’s unconventional policy has strengthened the positive link between the growth of bank lending and capital ratios in European banks. While some of the literature on capital effects on bank lending examines the effects of bank liquidity on this link, the issue of QE policy impact on it until now has received very limited attention. In this light, findings of the present thesis will allow researchers, bank supervisors and policymakers to better understand the effects of the ECB’s large-scale asset purchase program on this important relationship in the area of the intersection of banking, financial regulation and monetary policy. This, in turn, can contribute to designing better informed monetary and macroprudential policies and bank regulations.

Chapter 1 reviews the literature with regard to bank capital as a determinant of bank lending. Using a stylized balance sheet of a commercial bank, it is shown that bank profitability which in theory is the main supply-side determinant of bank lending is highly procyclical. This view is consistent with financial accelerator hypothesis also presented and discussed in this chapter. In Chapter 1, I argue that lending activities of banks can actually be constrained by capital rather than central bank reserves. In essence, the central bank in its lender-of-last-resort function has to fully accommodate the demand for reserves to ensure the financial stability and smooth functioning of the payment system. Additionally, the existence of interbank market for bank reserves makes it a relatively cheap source of funding. In contrast, equity finance is limited in size and costly. Issuing new equity to raise additional bank capital, in particular during crises or economic downturns[80].

[79] The goal of this program was to easy liquidity conditions for banks, support the monetary policy transmission and ensure price stability in the euro area.
[80] For all of these reasons, fulfilling the capital adequacy requirements (imposed at the international level by the Basel Committee on Banking Supervision) is significantly more expensive and restrictive than

In Chapter 1, I provide theoretical background and empirical evidence on the effects of capital ratio. In the aftermath of the 1990-1991 recession, Bernanke & Lown (1991) put forward the 'credit crunch' hypothesis[81]. Syron (1991), who at the time was the President of Federal Reserve Bank of Boston, proposed a term 'capital crunch' to describe it. He argued that a sudden and sharp decline in bank credit was a consequence (rather than a cause) of the capital crunch in the US banking sector (Syron, 1991, p. 4). Consequently, the issue of sign of the relationship between bank lending and capital ratio emerged as an important research question. Based on the literature review, I formulate five research questions. In particular, they concern the potential non-linear nature of the studied relationship, the sign of it, and the relevance of its bank-specific determinants such as bank's size and specialization, bank's initial level of capitalization, and bank's relative liquidity position expressed in its liquidity ratios.

Chapter 2 conducts a literature review on the monetary policy as a determinant of bank lending and, based on it, formulates empirical hypotheses. Since the early 1990s and after the outburst of Global Financial Crisis, a large body of the literature and empirical research have emerged to describe, analyze and draw policy implications in the field of the credit channel of monetary policy. In this chapter, I point to a number of academic articles and papers that in fact focused on a separate channel within the credit channel, that is the bank capital channel of the monetary policy transmission (see Borio & Zhu, 2012; Markovic, 2006; Meh, 2011; Van den Heuvel, 2009).

Based on the original general monetary policy transmission mechanism, and building on the 'decoupling principle' of Borio & Disyatat (2009), I examined effects of conventional and unconventional monetary policy. Direct effects of unconventional monetary policy such as QE works mainly via the portfolio rebalance effect, within which the scarcity, signaling and duration effects can be distinguished. All of them are interdepended and not mutually exclusive, as argued in for example Bailey, Bridges, Harrison, Jones, & Mankodi (2020). The ultimate outcome of these three effects is to

satisfying the reserve requirements (imposed at the national level by domestic central banks). As a result, the capital requirements are more binding and can effectively impede the growth of bank lending, in particular when banks suffer large and numerous credit default losses and are unable or reluctant to issue new bank equity.

[81] Although, they admitted that observed phenomenon of a credit crunch might be better described as the 'capital crunch' (Bernanke & Lown, 1991, p. 206).

directly reduce long-term interest rate, i.e. it leads to decreased yields (and increased asset prices) on bonds and other debt instruments being purchased[82].

However, such a decline in long-term interest rates is not necessarily transmitted through the bank lending channel into lower loan rates and higher growth of bank loans (see Butt, Churm, McMahon, Morotz, & Schanz (2014); Gambacorta & Marques-Ibanez (2011). Instead, in the environment of very low interest rates, the QE policy seems to work mainly via the portfolio rebalance and bank risk-taking channel, producing still further increases in prices of private risky assets, through the 'search for yields' phenomenon and an inertia in nominal return targets (Gambacorta, 2009). All in all, this analysis shows the importance of bank capital for monetary transmission mechanism (i.e., the bank capital channel). This insight is in line with conclusions of Gambacorta & Shin (2018) who found that a 1-percentage point increase in the bank equity capital ratio (equity-to-total assets ratio) leads to four basis points reduction in bank debt funding and 0.6 percentage points increase in annual loan growth of European banks (Gambacorta & Shin, 2018, p. 17). This result suggests that if the banking sector is undercapitalized or weakly capitalized as a whole, both conventional and unconventional monetary policy transmission is impeded, and thus it is becoming ineffective in boosting bank lending.

In Chapter 3, I describe methodology of the empirical research conducted in the thesis. A range of panel data estimators including within-groups and between fixed effects estimators are carefully described and assessed. Next, data sources and definitions of variables are provided. Chapter 3 also shows the initial data treatment which involves constructing bank-specific and country-specific categories; management of data outliers using winsorization and identifying and dealing with mergers and acquisitions (M&As). Preliminary statistical analysis conducted on the final unconsolidated data indicates high heterogeneity among banks with regard to bank's size. The analysis confirms that the growth rate of loans supplied by small banks has exhibited on average higher amplitude of fluctuations in comparison to large and medium-sized banks. Chapter 3 concludes by

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[82] It is worth noting that according to studies of Gagnon, Raskin, Remache, & Sack (2011), Joyce, Lasaosa, Stevens, & Tong (2011), D'Amico & King (2013), and Christensen & Rudebusch (2012) the QE purchases reduce yields on US 10-year Treasury bonds or UK 10-year gilts by between 50 to 100 basis points. This negative effect on yields is statistically significant but as argued in Ryan & Whelan (2021) "economically modest".

pointing out that a median small bank over the 2012-2018 period held on average a significantly higher amount of equity capital in relation to total assets than large banks[83].

Chapter 4 describes the main research results, interprets them and discusses the findings and linking them to the relevant literature. Estimated fixed-effects econometric models with interaction terms, i.e. interactive models, are based on the sample of annual data obtained from a major banking database – adjusted for outliers and M&As – which in its final form contains institution-level information on up to 2,335 banks from 47 European countries observed in the 2011-2018 period[84]. The empirical investigation carried out in Chapter 4 has brought several important findings. Above all, the obtained results indicate that the QE policy adopted by the ECB was indeed a significant factor that affects the relationship between bank loans growth and the key capital adequacy ratios. In Chapter 4, five research questions have been answered. Controlling for effects of macroeconomic variables, changes in the conventional monetary policy (interest rates shocks) and macroprudential policy, proxied by the macroprudential policy index created by Cerutti et al. (2015), the results show that in the 2011-2018 period the relationship between bank capital ratios and lending growth of European banks depended on a number of bank-specific characteristics, namely on the bank size and specialization, bank's initial level of capitalization, and bank liquidity ratios.

In the estimated dynamic linear-multiplicate models several interactions terms that moderate this relationship were found significant. This confirms the previous findings in the literature that the relationship between bank loans growth and bank capital ratios is essentially non-linear. The sign of this relationship is found to be contingent on the adopted measure of a capital ratio. Regulatory capital ratios such as Tier 1 ratio and Total capital ratio exert a significantly positive effect on bank lending, while the equity capital ratio affects the net loans growth negatively. This finding is robust to using the alternative liquidity ratio. Therefore, it can be viewed as an important contribution to the relevant literature. This finding implies that efforts of regulators and macroprudential policymakers are effective in constraining bank lending only when they impose restrictions on banks in reference to the capital adequacy requirements set by the Basel Committee on Banking Supervision.

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[83] In the 2012-2018 period, the equity capital ratio of a median small bank was on average equal to 13.04% whereas the ECR of a median large bank averaged 8.65%.

[84] Hence, the number of total observations in the final sample of unconsolidated data equals N = 11,597.

Chapter 4 successfully contributes to the achievement of the objective of the present thesis. In this Chapter, I estimated models with bank-specific and country-specific interactions allowed me to verify five empirical hypotheses developed in Chapter 2. These empirical hypotheses are as follows:

1. The effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB.
2. The effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for large banks with sufficient level of liquidity.
3. The effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for well-capitalized banks with sufficient level of liquidity.
4. The effect of bank capital ratios on bank lending is negatively associated with the Quantitative Easing policy of the ECB only for banks from countries characterized by more restrictive capital regulations and more stringent overall restrictions on banking activities.
5. The effect of bank capital ratios on bank lending is positively associated with the Quantitative Easing policy of the ECB only for banks from countries characterized by more concentrated structure of the banking sector and higher share of state-owned banks.

The major finding of the thesis is that unconventional monetary policy in the form of the Asset Purchase Program of the ECB has strengthen the positive link between regulatory capital ratios and bank loan growth. Thus, it implies a rejection of Hypothesis 1. In ECR regression, the ECB's QE policy significantly enhances the effect of an increase in the bank equity capital on the growth rate of lending by European banks. Since these effects are robust across all of the adopted measure of capital ratio to using an alternative liquidity ratio, this finding can be an important contribution to the literature.

This evidence also points to some important policy implications. The quantitative easing policy in Europe has been successful in making banks more responsive to capital ratios in their lending activities. The QE policy of the ECB has thus effectively contributed to removing a liquidity constraint for less liquid banks, but on the other hand, it has made them less resilient (i.e., more responsive) to capital shocks. This evidence implies that policy actions should be aimed both at improving bank liquidity ratios (by means of the QE-style central bank balance sheet policies) and simultaneously at providing banks with resources to strengthen their capital ratios by official state-contingent capital injections or bank equity purchases programs. This evidence also reinforces the conclusions of Thornton & Tommaso (2020) that bank capital and liquidity position are complementary, mutually depended and crucially important for European banks to sustain the growth of bank credit and lending. Another policy recommendation would be as follows. To prevent the build-up of imbalances in the macroeconomy, regulators and bank supervisors should constantly monitor the level of bank capitalization, both at the individual and system-wide level, because any adverse capital shocks can be swiftly propagated to the real economy via a severe decline in bank credit and the resulting slowdown in economic growth.

In Chapter 4, I obtained results suggesting that Hypothesis 2 and Hypothesis 3 can only be partly accepted, hence as such they shall be rejected. Nonetheless, the revealed empirical evidence has enabled me to adjust them and restate them in a form consistent with obtained findings. These can be summarized in a few points. Regarding both Hypotheses 2 and 3, first of all, the positive impact of the QE is higher in regressions with regulatory binding risk-based ratios than in regressions with the equity capital ratio. Second, the most pronounced positive effects of QE are detected for small banks with low level of liquidity, and for banks with the medium level of initial capital ratio. Third, the least responsive in their lending to capital shocks are well-capitalized banks, for which the positive impact of QE is the most limited. Fourth, the positive QE effects diminishes as bank liquidity increases. This evidence allows to draw an important policy recommendation. Proposed state-contingent official capital injections or bank equity purchases programs should focus on providing additional bank equity especially for banks with low and medium level of capital ratios. Moreover, the ECB’s QE policy is the most effective in strengthening the link between capital ratios and lending growth when applied to small banks experiencing liquidity constraints.

Chapter 4 also highlights the importance of the examined country-specific variables. The results have confirmed both Hypothesis 4 and Hypothesis 5. They show that in the case of regulatory capital ratios the effect of bank capital ratios on bank lending is negatively associated with the QE policy for banks from countries characterized by more restrictive capital regulations and more stringent restrictions on banking activities. On the other hand, the effect of bank capital ratios on bank lending is found to be positively associated with the QE policy only for banks from countries with small concentration of the banking sector and with low share of state-owned banks. Regarding both Hypotheses 4 and 5, importantly, the examined effects of the QE policy tend to be unrelated to the level of bank liquidity ratios, across all of the adopted measures of capital ratio.

There are some limitations of the conducted study. They can be linked to various possible directions for future research. As mentioned in the discussion section of the previous chapter, due to some specific data limitations such as a relatively short time period of the panel, the binary variable that proxies the ECB's quantitative easing policy may have captured only a general country-related effect of this unconventional policy. In future research, it could be replaced with one or all subprograms of the ECB's APP program as a continuous (stock) variable or a flow variable.

Second, in the aftermath of the world pandemic in 2020, many central banks have launched or significantly updated their asset purchases programs. Relatedly, future research can use recent international QE experiences to compare the QE effects on the link between bank ratios and loan growth in different countries and using a richer panel of data. Increased number of time periods would allow researchers to apply various other estimators and econometric techniques, such as the GMM estimator or panel VAR model.

Finally, different country-specific factors could be explored as potential determinants of effects of the QE policy on the examined relationship. For example, in the future research a degree of capitalization of the whole banking sector could be exploited and checked in the interactive models for its consequences for general results. The other research could focus on matching different combinations of country-specific factors than proposed in this thesis. It is important to examine these proposals to ensure that policymakers can appropriately design unconventional monetary policy measures to achieve the desired goals of financial and price stability.

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Annex

Table A.1. Pearson's correlation coefficients of bank-specific variables (set Ia)

	loans_rel	DLloans	dloans	ECR	Tier1ratio	TCR
loans_rel	1.000 (11,446)					
DLloans	0.171* (11,417)	1.000 (11,417)				
dloans	0.068* (11,419)	0.951* (11,417)	1.000 (11,419)			
ECR	-0.290* (11,418)	-0.215* (11,390)	-0.122* (11,392)	1.000 (11,564)		
Tier1ratio	-0.245* (6,738)	-0.075* (6,728)	-0.015 (6,728)	0.647* (6,747)	1.000 (6,753)	
TCR	-0.305* (7,983)	-0.168* (7,971)	-0.077* (7,971)	0.700* (8,008)	0.964* (6,710)	1.000 (8,015)

Notes: * denotes Pearson product-moment correlation coefficients that are statistically significant at 5% significance level. Numbers in parentheses indicate the number of observations in each pair of variables. Maximum number of observations in the panel is N = 11,597.
Source: own elaboration.

Table A.2. Spearman's correlation coefficients of bank-specific variables (set Ia)

	loans_rel	DLloans	dloans	ECR	Tier1ratio	TCR
loans_rel	1.000					
DLloans	0.104*	1.000				
dloans	0.104*	1.000*	1.000			
ECR	-0.077*	-0.109*	-0.109*	1.000		
Tier1ratio	-0.205*	-0.057*	-0.057*	0.663*	1.000	
TCR	-0.249*	-0.060*	-0.060*	0.639*	0.914*	1.000

Notes: * denotes Spearman rank-order correlation coefficients that are statistically significant at 5% significance level.
Source: own elaboration.

Table A.3. Pearson's correlation coefficients of bank-specific variables (set Ib)

	Deposits_rel	LTD	MFUND	PBT_rel	ROE	ROA	LADSTF	LATDB
Deposits_rel	1.000 (11,304)							
LTD	-0.536* (11,258)	1.000 (11,258)						
MFUND	-0.808* (11,275)	0.472* (11,230)	1.000 (11,275)					
PBT_rel	-0.086* (11,265)	0.050* (11,219)	-0.029* (11,238)	1.000 (11,558)				
ROE	0.031* (11,239)	0.034* (11,194)	-0.024* (11,239)	0.750* (11,521)	1.000 (11,522)			
ROA	-0.070*	0.046*	-0.033*	0.986*	0.760*	1.000		

	(11,266)	(11,220)	(11,239)	(11,552)	(11,522)	(11,553)		
LADSTF	-0.309* (11,255)	0.025* (11,218)	-0.014 (11,230)	0.123* (11,354)	0.012 (11,330)	0.111* (11,355)	1.000 (11,389)	
LATDB	-0.276* (7,759)	0.026* (7,742)	-0.006 (7,744)	0.112* (7,893)	0.022* (7,878)	0.098* (7,893)	0.946* (7,854)	1.000 (7,914)

Notes: * denotes Pearson product-moment correlation coefficients that are statistically significant at 5% significance level. Numbers in parentheses indicate the number of observations in each pair of variables. Maximum number of observations in the panel is N = 11,597.
Source: own elaboration.

Table A.4. Spearman's correlation coefficients of bank-specific variables (set Ib)

	Deposits _rel	**LTD**	**MFUND**	**PBT_rel**	**ROE**	**ROA**	**LADSTF**	**LATDB**
Deposits_rel	1.000							
LTD	-0.568*	1.000						
MFUND	-0.824*	0.574*	1.000					
PBT_rel	-0.025*	0.010	-0.124*	1.000				
ROE	0.053*	0.015	-0.055*	0.840*	1.000			
ROA	-0.030*	0.009	-0.133*	0.939*	0.897*	1.000		
LADSTF	0.048*	-0.397*	-0.247*	0.160*	0.152*	0.229*	1.000	
LATDB	0.100*	-0.433*	-0.299*	0.163*	0.149*	0.227*	0.992*	1.000

Notes: * denotes Spearman rank-order correlation coefficients that are statistically significant at 5% significance level.
Source: own elaboration.

Table A.5. Pearson's correlation coefficients of bank-specific variables (set Ic)

	loans_rel	**DLloans**	**IBF**	**CBCB_rel**	**Provisions**	**NPL**
loans_rel	1.000 (11,446)					
DLloans	0.171* (11,417)	1.000 (11,417)				
IBF	-0.218* (7,838)	-0.011 (7,833)	1.000 (7,860)			
CBCB_rel	-0.350* (11,234)	-0.208* (11,211)	0.011 (7,735)	1.000 (11,325)		
Provisions	-0.103* (11,031)	-0.223* (11,012)	0.002 (7,612)	0.114* (10,921)	1.000 (11,031)	
NPL	-0.296* (7,878)	-0.243* (7,867)	0.036* (5,785)	0.209* (7,798)	0.288* (7,803)	1.000 (7,878)

Notes: * denotes Pearson product-moment correlation coefficients that are statistically significant at 5% significance level. Numbers in parentheses indicate the number of observations in each pair of variables. Maximum number of observations in the panel is N = 11,597.
Source: own elaboration.

Table A.6. Spearman's correlation coefficients of bank-specific variables (set Ic)

	loans_rel	**DLloans**	**IBF**	**CBCB_rel**	**Provisions**	**NPL**

loans_rel	1.000					
DLloans	0.088*	1.000				
IBF	-0.330*	-0.054*	1.000			
CBCB_rel	-0.093*	-0.040*	0.061*	1.000		
Provisions	-0.165*	-0.226*	0.034*	-0.013	1.000	
NPL	-0.237*	-0.250*	0.052*	-0.063*	0.512*	1.000

Notes: * denotes Spearman rank-order correlation coefficients that are statistically significant at 5% significance level.
Source: own elaboration.

Table A.7. Pearson's correlation coefficients of ECB's quantitative easing variables (set II)

	Deposits _rel	**loans _rel**	**DLloans**	**APP**	**pspp**	**abspp_f**	**cbpp3_f**	**cspp_f**
Deposits_rel	1.000 (11,304)							
loans_rel	0.114* (11,264)	1.000 (11,446)						
DLloans	0.146* (11,239)	0.171* (11,417)	1.000 (11,417)					
APP	0.039* (11,304)	0.084* (11,446)	0.091* (11,417)	1.000 (11,597)				
pspp	0.038* (11,304)	0.080* (11,446)	0.090* (11,417)	0.998* (11,597)	1.000 (11,597)			
abspp_f	-0.006 (11,304)	0.046* (11,446)	0.064* (11,417)	0.687* (11,597)	0.675* (11,597)	1.000 (11,597)		
cbpp3_f	0.036* (11,304)	0.081* (11,446)	0.067* (11,417)	0.751* (11,597)	0.723* (11,597)	0.863* (11,597)	1.000 (11,597)	
cspp_f	0.031* (11,304)	0.089* (11,446)	0.084* (11,417)	0.792* (11,597)	0.789* (11,597)	0.204* (11,597)	0.319* (11,597)	1.000 (11,597)

Notes: * denotes Pearson product-moment correlation coefficients that are statistically significant at 5% significance level. Numbers in parentheses indicate the number of observations in each pair of variables. Maximum number of observations in the panel is N = 11,597.
Source: own elaboration.

Table A.8. Spearman's correlation coefficients of ECB's quantitative easing variables (set II)

	Deposits _rel	**loans _rel**	**DLloans**	**APP**	**pspp**	**abspp_f**	**cbpp3_f**	**cspp_f**
Deposits_rel	1.000							
loans_rel	-0.084*	1.000						
DLloans	0.150*	0.110*	1.000*					
APP	0.012	0.114*	0.147*	1.000				
pspp	0.017	0.099*	0.153*	0.953*	1.000			
abspp_f	-0.122*	0.064*	0.094*	0.837*	0.768*	1.000		
cbpp3_f	-0.034*	0.139*	0.096*	0.920*	0.804*	0.852*	1.000	

cspp_f	-0.061*	0.081*	0.113*	0.702*	0.734*	0.621*	0.572*	1.000

Notes: * denotes Spearman rank-order correlation coefficients that are statistically significant at 5% significance level.
Source: own elaboration.

Table A.9. Pearson's correlation coefficients of micro and macro-prudential regulatory variables (set III)

	loans_rel	**DLloans**	**Act_restrict**	**Cap_reg**	**Sup_power**	**Bank_conc**	**Gov_banks**	**MPI**
loans_rel	1.000 (11,446)							
DLloans	0.171* (11,417)	1.000 (11,417)						
Act_restrict	0.034* (8,212)	0.068* (8,187)	1.000 (8,353)					
Cap_reg	0.028* (10,817)	-0.078* (10,788)	0.557* (8,189)	1.000 (10,963)				
Sup_power	0.163* (10,157)	0.320* (10,130)	0.154* (7,486)	-0.385* (10,096)	1.000 (10,260)			
Bank_conc	-0.043* (10,957)	0.003 (10,928)	0.355* (8,329)	-0.112* (10,963)	-0.001 (10,236)	1.000 (11,103)		
Gov_banks	-0.175* (10,919)	-0.165* (10,890)	-0.161* (8,291)	0.303* (10,925)	-0.559* (10,198)	-0.522* (11,065)	1.000 (11,065)	
MPI	0.180* (11,346)	0.183* (11,317)	0.120* (8,342)	-0.002 (10,952)	0.199* (10,260)	-0.057* (11,092)	-0.277* (11,054)	1.000 (11,492)

Notes: * denotes Pearson product-moment correlation coefficients that are statistically significant at 5% significance level. Numbers in parentheses indicate the number of observations in each pair of variables. Maximum number of observations in the panel is N = 11,597.
Source: own elaboration.

Table A.10. Spearman's correlation coefficients of micro and macro-prudential regulatory variables (set III)

	loans_rel	**DLloans**	**Act_restrict**	**Cap_reg**	**Sup_power**	**Bank_conc**	**Gov_banks**	**MPI**
loans_rel	1.000							
DLloans	0.138*	1.000						
Act_restrict	-0.024*	-0.027*	1.000					
Cap_reg	-0.059*	-0.163*	0.651*	1.000				
Sup_power	0.092*	0.210*	0.137*	-0.493*	1.000			
Bank_conc	0.041*	-0.010	0.691*	0.532*	0.006	1.000		
Gov_banks	-0.258*	-0.117*	-0.225*	-0.039*	-0.477*	-0.381*	1.000	
MPI	0.173*	0.206*	-0.060*	-0.045*	0.123*	-0.129*	-0.294*	1.000

Notes: * denotes Spearman rank-order correlation coefficients that are statistically significant at 5% significance level.
Source: own elaboration.

Table A.11. Pearson's correlation coefficients of macroeconomic control variables (set IV)

	loans_rel	**DLloans**	**GDP_growth**	**CPI**	**INT_ST**	**INT_LT**	**Recession**
loans_rel	1.000 (11,446)						
DLloans	0.171* (11,417)	1.000 (11,417)					
GDP_growth	0.011 (11,332)	0.185* (11,303)	1.000 (11,478)				
CPI	-0.119* (11,230)	-0.239* (11,201)	-0.510* (11,376)	1.000 (11,376)			
INT_ST	-0.253* (10,676)	-0.348* (10,656)	-0.333* (10,753)	0.860* (10,664)	1.000 (10,824)		
INT_LT	-0.279* (10,731)	-0.316* (10,711)	-0.412* (10,820)	0.758* (10,735)	0.930* (10,746)	1.000 (10,879)	
Recession	0.021* (11,446)	0.032* (11,417)	-0.379* (11,478)	0.016 (11,376)	-0.073* (10,824)	0.092* (10,879)	1.000 (11,597)

Notes: * denotes Pearson product-moment correlation coefficients that are statistically significant at 5% significance level. Numbers in parentheses indicate the number of observations in each pair of variables. Maximum number of observations in the panel is N = 11,597.
Source: own elaboration.

Table A.12. Spearman's correlation coefficients of macroeconomic control variables (set IV)

	loans_rel	**DLloans**	**GDP_growth**	**CPI**	**INT_ST**	**INT_LT**	**Recession**
loans_rel	1.000						
DLloans	0.104*	1.000					
GDP_growth	0.039*	0.136*	1.000				
CPI	-0.071*	-0.086*	-0.237*	1.000			
INT_ST	-0.165*	-0.226*	-0.389*	0.327*	1.000		
INT_LT	-0.238*	-0.204*	-0.395*	0.407*	0.700*	1.000	
Recession	0.001	-0.030*	-0.474*	0.266*	0.313*	0.295*	1.000

Notes: * denotes Spearman rank-order correlation coefficients that are statistically significant at 5% significance level.
Source: own elaboration.

Table B.1. Interaction effects of capital, liquidity, APP dummy and the bank size category

	L_t = Net loans (growth of logarithm)					
	Tier 1 capital /RWAs		Total capital /RWAs		Equity capital /Total assets	
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{CAP_{t-1}}$	-0.187	-0.344	-0.023	0.011	-0.570**	-0.675**

	(0.193)	(0.385)	(0.174	(0.280)	(0.282)	(0.334)
$\mathbf{LIQ_{t-1}}$	0.346** (0.142)	0.340** (0.146)	0.348*** (0.120)	0.364*** (0.121)	0.519*** (0.076)	0.517*** (0.076)
$\mathbf{CAP_{t-1}} \times \boldsymbol{Size\_category}[\mathbf{2}]$		-0.028 (0.373)		-0.064 (0.304)		0.099 (0.425)
$\mathbf{CAP_{t-1}} \times \boldsymbol{Size\_category}[\mathbf{3}]$		0.613 (0.542)		0.384 (0.558)		0.863 (0.972)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d}$	0.445** (0.174)	0.513*** (0.168)	0.336** (0.153)	0.383*** (0.558)	0.391 (0.240)	0.491* (0.259)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d} \times \boldsymbol{Size\_category}[\mathbf{2}]$		-0.132 (0.122)		-0.117 (0.113)		-0.192* (0.114)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d} \times \boldsymbol{Size\_category}[\mathbf{3}]$		-0.158 (0.151)		-0.168 (0.114)		-0.261 (0.220)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP_d}$	-0.208 (0.167)	-0.274** (0.125)	-0.142 (0.138)	-0.173 (0.113)	-0.129** (0.063)	-0.105* (0.062)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}}$	0.008*** (0.002)	0.008*** (0.003)	0.004* (0.002)	0.004 (0.003)	0.000 (0.002)	-0.001 (0.002)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{Size\_category}[\mathbf{2}]$		0.005 (0.004)		-0.001 (0.002)		0.004* (0.002)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{Size\_category}[\mathbf{3}]$		-0.012 (0.008)		-0.009 (0.008)		-0.017 (0.019)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.006 (0.006)	-0.003 (0.003)	-0.005 (0.005)	-0.003 (0.003)	-0.006 (0.004)	-0.008 (0.004)
Observations	4,931	4,931	5,586	5,586	8,063	8,063
Adjusted $\mathbf{R^2}$	0.244	0.251	0.200	0.202	0.160	0.163
No. of panels	1,350	1,350	1,530	1,530	2,022	2,022
Macroeconomic control variables	YES					
Bank-specific characteristics	YES					
Bank fixed effects and yearly dummies	YES					

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. RWAs denotes bank risk-weighted assets. Numbers in the square brackets are categories of given variables. Size_category[3] denotes large banks, Size_category[2] denotes medium-sized banks, and Size_category[1] which is a reference category involves only small banks. An empty table cell indicates that an interaction term is intentionally not included in the regression.
Source: own elaboration.

Table B.2. Interaction effects of capital, liquidity, APP dummy and the bank specialization

	$\boldsymbol{L_t}$ = Net loans (growth of logarithm)		
	Tier 1 capital /RWAs	Total capital /RWAs	Equity capital /Total assets

	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{CAP_{t-1}}$	-0.187 (0.193)	-0.065 (0.290)	-0.023 (0.174	0.093 (0.232)	-0.570** (0.282)	-0.404 (0.300)
$\mathbf{LIQ_{t-1}}$	0.346** (0.142)	0.387** (0.160)	0.348*** (0.120)	0.382*** (0.134)	0.519*** (0.076)	0.609*** (0.091)
$\mathbf{CAP_{t-1}} \times \boldsymbol{Specialization}[\mathbf{2}]$		0.011 (0.319)		-0.126 (0.300)		-0.904* (0.492)
$\mathbf{CAP_{t-1}} \times \boldsymbol{Specialization}[\mathbf{3}]$		-0.837** (0.345)		-0.598** (0.289)		-0.282 (0.391)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d}$	0.445** (0.174)	0.663** (0.307)	0.336** (0.153)	0.474 (0.295)	0.391 (0.240)	0.671 (0.497)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d} \times \boldsymbol{Specialization}[\mathbf{2}]$		-0.288 (0.205)		-0.123 (0.203)		-0.174 (0.344)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d} \times \boldsymbol{Specialization}[\mathbf{3}]$		-0.220 (0.211)		-0.212 (0.200)		-0.340 (0.319)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP_d}$	-0.208 (0.167)	-0.159 (0.163)	-0.142 (0.138)	-0.097 (0.131)	-0.129** (0.063)	-0.074 (0.074)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}}$	0.008*** (0.002)	0.007*** (0.003)	0.004* (0.002)	0.003 (0.002)	0.000 (0.002)	-0.002 (0.002)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{Specialization}[\mathbf{2}]$		-0.008 (0.006)		-0.008 (0.005)		-0.040*** (0.009)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{Specialization}[\mathbf{3}]$		0.002 (0.005)		0.003 (0.004)		-0.008 (0.008)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.006 (0.006)	-0.008 (0.007)	-0.005 (0.005)	-0.007 (0.006)	-0.006 (0.004)	-0.008 (0.005)
Observations	4,931	4,931	5,586	5,586	8,063	8,063
Adjusted $\mathbf{R^2}$	0.244	0.249	0.200	0.203	0.160	0.167
No. of panels	1,350	1,350	1,530	1,530	2,022	2,022
Macroeconomic control variables	YES					
Bank-specific characteristics	YES					
Bank fixed effects and yearly dummies	YES					

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. RWAs denotes bank risk-weighted assets. Numbers in the square brackets are categories (levels) of given variables. Specialization[2] denotes cooperative banks, Specialization[3] denotes savings banks, and Specialization[1] which is a reference category involves commercial banks. An empty table cell indicates that an interaction term is intentionally not included in the regression.
Source: own elaboration.

Table B.3. Interaction effects of capital, liquidity, APP dummy and the bank capital category

	L_t = **Net loans (growth of logarithm)**					
	Tier 1 capital /RWAs		Total capital /RWAs		Equity capital /Total assets	
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{CAP_{t-1}}$	-0.187 (0.193)	0.341 (0.446)	-0.023 (0.174	0.785** (0.373)	-0.570** (0.282)	-0.643 (0.783)
$\mathbf{LIQ_{t-1}}$	0.346** (0.142)	0.343*** (0.129)	0.348*** (0.120)	0.331*** (0.120)	0.519*** (0.076)	0.450*** (0.080)
$\mathbf{CAP_{t-1}} \times \boldsymbol{Capital}[\mathbf{2}]$		-1.328*** (0.448)		-1.439*** (0.375)		-1.298 (0.929)
$\mathbf{CAP_{t-1}} \times \boldsymbol{Capital}[\mathbf{3}]$		-0.621 (0.423)		-0.880** (0.383)		0.102 (0.778)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d}$	0.445** (0.174)	0.641*** (0.208)	0.336** (0.153)	0.377** (0.160)	0.391 (0.240)	0.607 (0.374)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d} \times \boldsymbol{Capital}[\mathbf{2}]$		0.194 (0.163)		0.200 (0.123)		0.050 (0.182)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d} \times \boldsymbol{Capital}[\mathbf{3}]$		-0.199** (0.090)		-0.049 (0.082)		-0.140 (0.189)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP_d}$	-0.208 (0.167)	-0.265* (0.141)	-0.142 (0.138)	-0.146 (0.123)	-0.129** (0.063)	-0.128** (0.060)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}}$	0.008*** (0.002)	-0.006 (0.008)	0.004* (0.002)	-0.008 (0.006)	0.000 (0.002)	-0.001 (0.003)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{Capital}[\mathbf{2}]$		0.028* (0.015)		0.028** (0.011)		0.036* (0.019)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{Capital}[\mathbf{3}]$		0.015** (0.007)		0.012** (0.006)		0.002 (0.003)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.006 (0.006)	-0.003 (0.004)	-0.005 (0.005)	-0.004 (0.004)	-0.006 (0.004)	-0.007* (0.004)
Observations	4,931	4,467	5,586	5,001	8,063	7,417
Adjusted $\mathbf{R^2}$	0.244	0.264	0.200	0.217	0.160	0.169
No. of panels	1,350	1,086	1,530	1,200	2,022	1,658
Macroeconomic control variables	YES					
Bank-specific characteristics	YES					
Bank fixed effects and yearly dummies	YES					

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. RWAs denotes bank risk-weighted assets.
Numbers in the square brackets are categories (levels) of given variables. Capital[3] denotes highly capitalized banks, Capital[2] denotes medium-capital banks, and Capital[1] which is a reference category

that involves poorly capitalized banks. An empty table cell indicates that an interaction term is intentionally not included in the regression.
Source: own elaboration.

Table B.4. Interaction effects of capital, liquidity, APP dummy and the bank liquidity category

	L_t = Net loans (growth of logarithm)					
	Tier 1 capital /RWAs		Total capital /RWAs		Equity capital /Total assets	
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{CAP_{t-1}}$	-0.187 (0.193)	-0.664** (0.275)	-0.023 (0.174	-0.190 (0.300)	-0.570** (0.282)	-1.001** (0.451)
$\mathbf{LIQ_{t-1}}$	0.346** (0.142)	0.342** (0.153)	0.348*** (0.120)	0.349*** (0.115)	0.519*** (0.076)	0.508*** (0.081)
$\mathbf{CAP_{t-1}} \times \boldsymbol{Liquidity}[\mathbf{2}]$		0.286 (0.306)		0.093 (0.345)		0.141 (0.499)
$\mathbf{CAP_{t-1}} \times \boldsymbol{Liquidity}[\mathbf{3}]$		1.024** (0.410)		0.409 (0.385)		0.868 (0.532)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d}$	0.445** (0.174)	0.444** (0.191)	0.336** (0.153)	0.303* (0.163)	0.391 (0.240)	0.451** (0.198)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d} \times \boldsymbol{Liquidity}[\mathbf{2}]$		-0.002 (0.120)		0.043 (0.109)		-0.156 (0.095)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP_d} \times \boldsymbol{Liquidity}[\mathbf{3}]$		-0.236 (0.177)		-0.106 (0.167)		0.060 (0.238)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP_d}$	-0.208 (0.167)	-0.221 (0.167)	-0.142 (0.138)	-0.159 (0.132)	-0.129** (0.063)	-0.118 (0.073)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}}$	0.008*** (0.002)	0.013*** (0.004)	0.004* (0.002)	0.004 (0.004)	0.000 (0.002)	0.002 (0.003)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{Liquidity}[\mathbf{2}]$		-0.005 (0.005)		0.002 (0.004)		0.000 (0.003)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{Liquidity}[\mathbf{3}]$		-0.008* (0.004)		-0.001 (0.003)		-0.003 (0.003)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.006 (0.006)	-0.006 (0.006)	-0.005 (0.005)	-0.004 (0.005)	-0.006 (0.004)	-0.007* (0.004)
Observations	4,931	4,931	5,586	5,586	8,063	8,063
Adjusted $\mathbf{R^2}$	0.244	0.250	0.200	0.202	0.160	0.162
No. of panels	1,350	1,350	1,530	1,530	2,022	2,022
Macroeconomic control variables	YES					
Bank-specific characteristics	YES					
Bank fixed effects and yearly dummies	YES					

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. ***, **

and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. RWAs denotes bank risk-weighted assets.
Numbers in the square brackets are categories (levels) of given variables. Liquidity[3] denotes banks characterized by low liquidity, Liquidity[2] denotes medium-liquidity banks, and Liquidity[1] which is a reference category that involves high-liquidity banks. An empty table cell indicates that an interaction term is intentionally not included in the regression.
Source: own elaboration.

Table C.1. Interaction effects of capital, liquidity, APP dummy, and country-specific factors such as regulatory and other restrictions on banking activities

	L_t = Net loans (growth of logarithm)					
	Tier 1 capital /RWAs		Total capital /RWAs		Equity capital /Total assets	
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{CAP_{t-1}}$	-5.401* (2.913)	-7.076** (3.336)	-5.899*** (1.926)	-7.028*** (2.129)	-1.095 (0.742)	-0.278 (0.753)
$\mathbf{LIQ_{t-1}}$	0.228 (0.139)	0.331 (0.203)	0.207* (0.125)	0.278* (0.158)	0.422*** (0.086)	0.504*** (0.091)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP\_d}$		8.398** (3.807)		10.074*** (2.419)		-4.467*** (1.174)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$		-0.090 (0.228)		-0.080 (0.176)		-0.142 (0.087)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}}$	0.006* (0.004)	0.008** (0.004)	0.005* (0.003)	0.005* (0.003)	0.001 (0.002)	0.000 (0.002)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$		-0.008 (0.008)		-0.006 (0.007)		-0.003 (0.005)
$\mathbf{CAP_{t-1}} \times \mathbf{Cap\_reg[2]}$	0.015 (1.965)	5.376* (2.911)	0.290 (0.451)	-0.605 (1.569)	-1.326 (0.936)	-2.741*** (0.810)
$\mathbf{CAP_{t-1}} \times \mathbf{Cap\_reg[2]} \times \boldsymbol{APP\_d}$		-3.223 (3.555)		0.797 (2.080)		1.617 (1.346)
$\mathbf{CAP_{t-1}} \times \mathbf{Cap\_reg[3]}$	-0.825 (2.872)	0.362 (5.383)	-0.918* (0.546)	-1.634 (1.573)	-1.952** (0.896)	-2.563*** (0.540)
$\mathbf{CAP_{t-1}} \times \mathbf{Cap\_reg[3]} \times \boldsymbol{APP\_d}$		-8.171 (6.588)		-7.906** (3.214)		5.733** (2.414)
$\mathbf{CAP_{t-1}} \times \mathbf{Act\_restrict[2]}$	5.700*** (2.042)	1.634 (2.800)	5.606*** (1.928)	7.532*** (2.636)	1.793** (0.860)	2.469*** (0.563)
$\mathbf{CAP_{t-1}} \times \mathbf{Act\_restrict[2]} \times \boldsymbol{APP\_d}$		4.467** (1.959)		-1.717 (1.816)		-1.959* (1.186)
$\mathbf{CAP_{t-1}} \times \mathbf{Act\_restrict[3]}$	5.588** (2.773)	1.731 (3.749)	4.873** (1.935)	6.653** (2.602)	2.100** (0.988)	2.749*** (0.823)

$\mathbf{CAP_{t-1}}$ $\times$ **Act_restrict**[3] $\times$ $\boldsymbol{APP\_d}$		1.741 (3.766)		-1.736 (2.153)		-1.231 (1.339)
$\mathbf{CAP_{t-1}}$ $\times$ **Sup_power**[2]	-0.119 (1.538)	4.425 (2.879)	1.576*** (0.434)	1.884*** (0.550)	4.504*** (1.274)	2.583** (1.206)
$\mathbf{CAP_{t-1}}$ $\times$ **Sup_power**[2] $\times$ $\boldsymbol{APP\_d}$		-4.641 (3.308)		-0.213 (1.391)		1.471** (0.728)
$\mathbf{CAP_{t-1}}$ $\times$ **Sup_power**[3]	-0.032 (2.011)	-0.102 (2.518)	0.937*** (0.283)	0.874*** (0.314)	-0.258 (0.619)	-0.534 (0.657)
$\mathbf{CAP_{t-1}}$ $\times$ **Sup_power**[3] $\times$ $\boldsymbol{APP\_d}$		-6.446 (3.720)		-8.642*** (2.302)		4.561*** (1.187)
Observations	2,149	2,149	2,755	2,755	5,124	5,124
Adjusted $\mathbf{R^2}$	0.304	0.316	0.248	0.254	0.169	0.176
No. of panels	568	568	739	739	1,201	1,201
Macroeconomic control variables	YES					
Bank-specific characteristics	YES					
Bank fixed effects and yearly dummies	YES					

Notes: The table reports estimated coefficients and statistics from fixed effects regressions with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. RWAs denotes bank risk-weighted assets. Numbers in the square brackets are categories (levels) of given variables. For example, Cap_reg[3] denotes that the degree of capital regulation stringency is large, and Sup_power[3] involves banks from countries where the official financial supervisory power is large. An empty table cell indicates that an interaction term is intentionally not included in the regression.
Source: own elaboration.

Table C.2. Interaction effects of capital, liquidity, APP dummy and country-specific market structure characteristics

	$\boldsymbol{L_t}$ = **Net loans (growth of logarithm)**					
	Tier 1 capital /RWAs		Total capital /RWAs		Equity capital /Total assets	
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{CAP_{t-1}}$	-2.947** (1.153)	-4.423*** (1.511)	0.005 (0.715)	0.288 (0.798)	-1.430** (0.613)	-0.866 (1.044)
$\mathbf{LIQ_{t-1}}$	0.205* (0.120)	0.380** (0.178)	0.243** (0.104)	0.358*** (0.133)	0.409*** (0.077)	0.506*** (0.082)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP\_d}$		1.533** (0.700)		0.745 (0.753)		0.760* (0.450)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$		-0.215 (0.192)		-0.181 (0.147)		-0.136* (0.076)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}}$	0.006*	0.007*	0.004*	0.004	0.001	0.000

	(0.004)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$		-0.006 (0.007)		-0.003 (0.006)		-0.005 (0.005)
$\mathbf{CAP_{t-1}} \times \mathbf{Bank\_conc[2]}$	1.049* (0.589)	0.937 (0.613)	0.544* (0.282)	0.471 (0.328)	0.215 (0.429)	0.861* (0.451)
$\mathbf{CAP_{t-1}} \times \mathbf{Bank\_conc[2]} \times \boldsymbol{APP\_d}$		2.294 (2.049)		-2.009 (1.585)		-1.626 (1.338)
$\mathbf{CAP_{t-1}} \times \mathbf{Bank\_conc[3]}$	3.118*** (1.159)	4.373*** (1.521)	0.207 (0.713)	-0.283 (0.798)	1.088* (0.568)	0.514 (0.780)
$\mathbf{CAP_{t-1}} \times \mathbf{Bank\_conc[3]} \times \boldsymbol{APP\_d}$		-1.134 (0.698)		-0.400 (0.756)		-0.237 (0.476)
$\mathbf{CAP_{t-1}} \times \mathbf{Gov\_banks[2]}$	0.191 (0.439)	0.495 (0.680)	-0.791* (0.427)	-0.547 (0.517)	0.168 (0.691)	0.511 (0.911)
$\mathbf{CAP_{t-1}} \times \mathbf{Gov\_banks[2]} \times \boldsymbol{APP\_d}$		-0.181 (0.574)		-0.210 (0.436)		-0.535 (0.477)
$\mathbf{CAP_{t-1}} \times \mathbf{Gov\_banks[3]}$	2.337** (1.157)	3.553** (1.520)	-0.332 (0.728)	-0.603 (0.807)	0.572 (0.419)	-0.562 (1.075)
$\mathbf{CAP_{t-1}} \times \mathbf{Gov\_banks[3]} \times \boldsymbol{APP\_d}$		-1.127 (0.689)		-0.593 (0.749)		-0.752 (0.508)
Observations	4,664	4,664	5,271	5,271	7,738	7,738
Adjusted $\mathbf{R^2}$	0.244	0.259	0.203	0.211	0.157	0.166
No. of panels	1,282	1,282	1,452	1,452	1,942	1,942
Macroeconomic control variables	YES					
Bank-specific characteristics	YES					
Bank fixed effects and yearly dummies	YES					

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. RWAs denotes bank risk-weighted assets. Numbers in the square brackets are categories (levels) of given variables. For example, Bank_conc[3] denotes that the degree of a banking system's concentration is high, and Gov_banks[3] involves banks from countries where there is a large degree of state-owned banks in the banking sector. An empty table cell indicates that an interaction term is intentionally not included in the regression.
Source: own elaboration.

Table D.1. Robustness check of baseline regression results for large banks estimated using consolidated and unconsolidated data

	Large banks ($\geq \mathbf{75}$%): consolidated data			Large banks ($\geq \mathbf{75}$%): unconsolidated data		
	Tier 1 ratio	TCR	ECR	Tier 1 ratio	TCR	ECR

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: L_t = Net loans (growth of logarithm)					
$\mathbf{L_{t-1}}$	-0.065 (0.043)	-0.040 (0.040)	-0.042 (0.036)	-0.019 (0.125)	-0.226* (0.126)	-0.124 (0.122)
$\mathbf{CAP_{t-1}}$	0.954 (0.588)	0.617 (0.531)	0.561 (0.606)	0.322 (0.556)	0.421 (0.536)	0.869 (1.400)
$\mathbf{LIQ_{t-1}}$	0.015 (0.056)	0.016 (0.054)	0.008 (0.078)	0.064 (0.161)	0.069 (0.168)	0.029 (0.162)
$\mathbf{Lsize_{t-1}}$	-5.385 (5.225)	-5.370 (5.219)	-4.641 (5.839)	-7.225 (12.182)	7.363 (13.838)	5.643 (12.765)
$\mathbf{ROA_{t-1}}$	-2.013 (1.252)	-1.394 (1.098)	-1.764 (1.123)	-0.154 (1.451)	-1.754 (2.572)	-2.026 (2.045)
$\mathbf{MFUND_{t-1}}$	-0.477*** (0.161)	-0.494*** (0.153)	-0.327** (0.149)	-0.552*** (0.149)	-0.560*** (0.168)	-0.299* (0.171)
$\mathbf{LTD_{t-1}}$	-2.740 (1.802)	-2.508** (1.112)	-3.867** (1.712)	0.250 (0.425)	0.429 (0.403)	0.069 (0.533)
$\mathbf{Provisions_{t-1}}$	-2.479** (1.072)	-2.237** (0.974)	-2.832*** (1.000)	-1.328* (0.673)	0.183 (1.118)	0.682 (1.069)
$\mathbf{\Delta GDP_{t-1}}$	0.195 (0.240)	0.123 (0.219)	0.032 (0.219)	2.111*** (0.506)	2.333*** (0.706)	2.237*** (0.569)
$\mathbf{\Delta INT\_ST_{t-1}}$	1.216 (0.777)	1.281* (0.667)	1.485** (0.735)	0.744 (2.640)	-0.891 (3.831)	-1.791 (3.175)
$\mathbf{CPI_{t-1}}$	1.774*** (0.477)	1.429*** (0.417)	1.294*** (0.474)	4.389*** (1.515)	5.182*** (1.747)	5.916*** (1.856)
$\mathbf{R_t}$	4.865 (3.362)	0.746 (2.889)	-1.209 (2.479)	3.040 (4.384)	-3.550 (5.141)	-8.719 (6.244)
$\mathbf{MPI_{\,t-1}}$	-0.019 (0.928)	-0.685 (0.776)	-0.591 (0.744)	2.400 (1.975)	-0.816 (2.254)	-2.201 (2.510)
Observations	991	1,239	1390	869	903	1,037
Adjusted $\mathbf{R^2}$	0.131	0.120	0.104	0.160	0.172	0.096
No. of panels	239	272	286	200	206	233
	Panel B: L_t = Net loans growth rate					
$\mathbf{L_{t-1}}$	-0.050 (0.032)	-0.024 (0.028)	-0.031 (0.033)	-0.010 (0.139)	-0.274 (0.166)	-0.067 (0.156)
$\mathbf{CAP_{t-1}}$	1.519 (0.943)	1.136 (0.773)	0.807 (0.927)	0.547 (0.789)	0.632 (0.763)	1.675 (1.912)
$\mathbf{LIQ_{t-1}}$	0.033 (0.061)	0.038 (0.057)	0.020 (0.087)	0.109 (0.149)	0.098 (0.154)	0.069 (0.164)
$\mathbf{Lsize_{t-1}}$	-5.221 (5.862)	-5.281 (5.600)	-4.608 (6.808)	-2.591 (15.466)	14.503 (17.128)	11.821 (17.335)
$\mathbf{ROA_{t-1}}$	-2.010 (1.313)	-1.485 (1.162)	-1.873 (1.359)	-1.462 (1.885)	-2.697 (2.876)	-3.216 (2.562)
$\mathbf{MFUND_{t-1}}$	-0.516***	-0.524***	-0.320*	-0.587***	-0.634***	-0.302*

	(0.195)	(0.178)	(0.177)	(0.169)	(0.186)	(0.176)
$\mathbf{LTD_{t-1}}$	-2.738 (1.778)	-2.325** (1.178)	-4.313* (2.200)	0.387 (0.475)	0.628 (0.487)	-0.018 (0.655)
$\mathbf{Provisions_{t-1}}$	-2.261** (0.971)	-2.130** (0.923)	-2.912** (1.160)	-2.294** (0.996)	0.185 (1.469)	1.234 (1.653)
$\mathbf{\Delta GDP_{t-1}}$	0.184 (0.234)	0.105 (0.208)	-0.029 (0.222)	2.101*** (0.697)	2.494** (1.007)	2.469*** (0.796)
$\mathbf{\Delta INT\_ST_{t-1}}$	1.154 (0.809)	1.297** (0.648)	1.420* (0.734)	1.529 (2.419)	-1.688 (3.959)	-2.048 (3.455)
$\mathbf{CPI_{t-1}}$	2.052*** (0.561)	1.641*** (0.454)	1.492*** (0.543)	3.538** (1.443)	5.503** (2.159)	6.357** (2.500)
$\mathbf{R_t}$	4.626 (3.472)	1.130 (3.044)	-1.817 (2.425)	6.368 (5.366)	-3.285 (6.507)	-10.016 (8.483)
$\mathbf{MPI_{\ t-1}}$	-0.190 (0.974)	-0.657 (0.790)	-0.310 (0.718)	3.486 (2.174)	-0.406 (2.500)	-2.777 (3.172)
Observations	991	1,239	1,390	869	903	1,037
Adjusted $\mathbf{R^2}$	0.167	0.158	0.106	0.153	0.176	0.081
No. of panels	239	272	286	200	206	233

Notes: The table reports estimated coefficients and statistics from fixed effects regression. Robust standard errors, clustered at the individual bank level, are reported in parentheses. All regressions include a constant term and yearly dummies, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. $\mathrm{LIQ_{t-1}}$ is a one-period lagged ratio of liquid assets to short-term funding (LADSTF).
Source: own elaboration.

Table D.2. Robustness check: interaction effects of capital, liquidity and APP dummy on bank loans growth for large banks

	Large banks ($\geq \mathbf{75\%}$): consolidated data			Large banks ($\geq \mathbf{75\%}$): unconsolidated data		
	Tier 1 ratio	TCR	ECR	Tier 1 ratio	TCR	ECR
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: L_t = Net loans (growth of logarithm)					
$\mathbf{L_{t-1}}$	-0.044 (0.047)	-0.025 (0.041)	-0.045 (0.036)	-0.024 (0.128)	-0.222* (0.129)	-0.132 (0.118)
$\mathbf{CAP_{t-1}}$	1.476*** (0.495)	1.255** (0.545)	0.203 (0.790)	0.591 (0.595)	0.797 (0.644)	-0.252 (0.859)
$\mathbf{LIQ_{t-1}}$	0.399 (0.274)	0.403 (0.245)	0.014 (0.139)	0.394 (0.280)	0.484 (0.316)	0.029 (0.338)
$\mathbf{Lsize_{t-1}}$	-9.358 (6.551)	-8.422 (5.913)	-5.030 (5.784)	-7.502 (11.975)	6.048 (13.781)	9.589 (14.255)
$\mathbf{ROA_{t-1}}$	-2.140* (1.264)	-1.541 (1.107)	-1.582 (1.205)	-0.289 (1.394)	-1.785 (2.321)	-1.408 (1.711)

$\mathbf{MFUND_{t-1}}$	-0.478*** (0.166)	-0.494*** (0.153)	-0.307** (0.147)	-0.513*** (0.146)	-0.531*** (0.170)	-0.350** (0.175)
$\mathbf{LTD_{t-1}}$	-2.558 (2.184)	-2.737** (1.300)	-3.986** (1.576)	0.168 (0.418)	0.388 (0.391)	0.281 (0.462)
$\mathbf{Provisions_{t-1}}$	-2.467** (1.054)	-2.248** (0.949)	-2.730*** (1.006)	-1.617** (0.724)	0.082 (1.113)	0.652 (1.088)
$\mathbf{CAP_{t-1} \times LIQ_{t-1}}$	-0.019 (0.014)	-0.017 (0.013)	-0.004 (0.013)	-0.007 (0.013)	-0.011 (0.013)	-0.004 (0.035)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP\_d}$	0.267 (0.191)	0.275 (0.171)	0.332 (0.326)	0.231 (0.221)	0.065 (0.178)	-0.438 (0.551)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.029 (0.183)	0.028 (0.244)	-0.103 (0.072)	-0.074 (0.149)	-0.194 (0.223)	-0.519** (0.237)
$\mathbf{CAP_{t-1} \times LIQ_{t-1}} \times \boldsymbol{APP\_d}$	0.000 (0.013)	-0.004 (0.014)	0.007 (0.011)	-0.004 (0.004)	0.001 (0.008)	0.080** (0.037)
Observations	991	1,239	1,390	869	903	1,037
Adjusted $\mathbf{R^2}$	0.144	0.146	0.108	0.189	0.195	0.128
No. of panels	239	272	286	200	206	233
	Panel B: L_t = Net loans growth rate					
$\mathbf{L_{t-1}}$	-0.046 (0.036)	-0.021 (0.029)	-0.028 (0.032)	-0.016 (0.143)	-0.274 (0.168)	-0.077 (0.152)
$\mathbf{CAP_{t-1}}$	1.625*** (0.574)	1.352** (0.637)	0.900 (1.125)	0.580 (0.775)	0.773 (0.813)	-0.329 (1.015)
$\mathbf{LIQ_{t-1}}$	0.282 (0.261)	0.322 (0.215)	0.109 (0.111)	0.230 (0.379)	0.314 (0.413)	-0.207 (0.421)
$\mathbf{Lsize_{t-1}}$	-7.773 (6.832)	-7.659 (5.824)	-5.663 (6.469)	-2.826 (15.327)	13.778 (17.365)	17.788 (19.369)
$\mathbf{ROA_{t-1}}$	-1.991* (1.193)	-1.516 (1.072)	-1.945 (1.507)	-1.436 (1.876)	-2.728 (2.744)	-2.602 (2.293)
$\mathbf{MFUND_{t-1}}$	-0.497** (0.195)	-0.514*** (0.173)	-0.315* (0.174)	-0.556*** (0.164)	-0.615*** (0.184)	-0.370** (0.182)
$\mathbf{LTD_{t-1}}$	-2.686 (2.097)	-2.431* (1.327)	-3.914** (1.887)	0.297 (0.466)	0.583 (0.476)	0.241 (0.545)
$\mathbf{Provisions_{t-1}}$	-2.170** (0.867)	-2.088** (0.831)	-2.887** (1.175)	-2.482** (1.065)	0.117 (1.444)	1.252 (1.693)
$\mathbf{CAP_{t-1} \times LIQ_{t-1}}$	-0.012 (0.014)	-0.012 (0.012)	-0.008 (0.013)	-0.001 (0.017)	-0.004 (0.016)	0.020 (0.039)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP\_d}$	0.330 (0.214)	0.331* (0.184)	0.415 (0.379)	0.279 (0.249)	0.097 (0.184)	-0.358 (0.582)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.125 (0.220)	-0.127 (0.273)	-0.084 (0.068)	0.054 (0.188)	-0.098 (0.231)	-0.442* (0.263)
$\mathbf{CAP_{t-1} \times LIQ_{t-1}} \times \boldsymbol{APP\_d}$	0.004 (0.015)	0.002 (0.015)	0.006 (0.012)	-0.007 (0.005)	-0.001 (0.008)	0.083* (0.043)

Observations	991	1,239	1,390	869	903	1,037
Adjusted $\mathbf{R^2}$	0.173	0.169	0.110	0.160	0.178	0.113
No. of panels	239	272	286	200	206	233

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. All regressions include a constant term, yearly dummies and macroeconomic control variables, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. $\mathrm{LIQ_{t-1}}$ is a one-period lagged ratio of liquid assets to short-term funding (LADSTF).

Table D.3. Robustness check of baseline regression results for commercial banks

	Commercial banks: consolidated data			**Commercial banks**: unconsolidated data		
	Tier 1 ratio	TCR	ECR	Tier 1 ratio	TCR	ECR
	(1)	(2)	(3)	(4)	(5)	(6)
	L_t = Net loans (growth of logarithm)					
$\mathbf{L_{t-1}}$	0.057 (0.087)	0.047 (0.072)	0.059 (0.060)	0.037 (0.046)	0.050 (0.048)	0.045 (0.042)
$\mathbf{CAP_{t-1}}$	0.417 (0.297)	0.088 (0.272)	-0.375 (0.335)	0.655*** (0.239)	0.496** (0.192)	-0.577** (0.264)
$\mathbf{LIQ_{t-1}}$	0.055 (0.082)	0.082 (0.085)	0.174** (0.068)	0.603*** (0.129)	0.506*** (0.092)	0.509*** (0.075)
$\mathbf{Lsize_{t-1}}$	-3.784 (7.364)	-6.555 (6.974)	-13.157** (6.224)	-8.120 (7.096)	-10.362* (5.923)	-21.650*** (5.540)
$\mathbf{ROA_{t-1}}$	1.300 (0.928)	1.775** (0.781)	1.009 (0.753)	1.287 (1.176)	-0.143 (0.803)	0.395 (0.621)
$\mathbf{MFUND_{t-1}}$	-0.560*** (0.156)	-0.579*** (0.178)	-0.364** (0.170)	-0.451*** (0.141)	-0.207 (0.131)	-0.114 (0.142)
$\mathbf{LTD_{t-1}}$	-0.654 (1.932)	-1.276 (1.618)	-2.550* (1.432)	-0.514 (0.605)	-1.779** (0.776)	-1.053 (0.661)
$\mathbf{Provisions_{t-1}}$	0.633 (1.082)	0.816 (0.750)	0.158 (0.721)	0.927 (0.584)	0.453 (0.401)	-0.267 (0.334)
$\mathbf{\Delta GDP_{t-1}}$	-0.148 (0.271)	-0.166 (0.255)	-0.095 (0.240)	0.696 (0.665)	-0.107 (0.770)	-0.533 (0.801)
$\mathbf{\Delta INT\_ST_{t-1}}$	1.619** (0.644)	1.682*** (0.588)	1.503** (0.581)	1.276 (1.097)	2.169*** (0.820)	1.604** (0.717)
$\mathbf{CPI_{t-1}}$	1.166** (0.491)	0.947** (0.420)	0.717* (0.417)	1.898** (0.882)	0.451 (0.612)	0.801 (0.575)
$\mathbf{R_t}$	2.819 (2.750)	1.429 (2.745)	1.783 (2.824)	2.159 (4.544)	-3.178 (4.407)	-5.189 (4.011)
$\mathbf{MPI_{t-1}}$	0.714 (0.935)	0.558 (0.851)	1.298 (0.863)	2.461 (1.881)	-0.240 (1.222)	0.381 (1.244)

Observations	774	890	1023	864	1,328	1,971
Adjusted $\mathbf{R^2}$	0.100	0.103	0.091	0.210	0.192	0.158
No. of panels	178	200	225	275	395	532

Notes: The table reports estimated coefficients and statistics from fixed effects regression. Robust standard errors, clustered at the individual bank level, are reported in parentheses. All regressions include a constant term and yearly dummies, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. $\mathrm{LIQ_{t-1}}$ is a one-period lagged ratio of liquid assets to short-term funding (LADSTF).
Source: own elaboration.

Table D.4. Robustness check of interactive effects of capital, liquidity and APP dummy on bank loans growth for commercial banks

	Commercial banks: consolidated data			**Commercial banks**: unconsolidated data		
	Tier 1 ratio	TCR	ECR	Tier 1 ratio	TCR	ECR
	(1)	(2)	(3)	(4)	(5)	(6)
	L_t = Net loans (growth of logarithm)					
$\mathbf{L_{t-1}}$	0.069 (0.087)	0.052 (0.070)	0.069 (0.059)	0.053 (0.047)	0.057 (0.049)	0.051 (0.042)
$\mathbf{CAP_{t-1}}$	1.023*** (0.348)	0.727** (0.360)	-0.319 (0.399)	-0.029 (0.333)	0.165 (0.253)	-0.365 (0.324)
$\mathbf{LIQ_{t-1}}$	0.306** (0.119)	0.316*** (0.112)	0.224** (0.106)	0.561*** (0.193)	0.471*** (0.154)	0.697*** (0.106)
$\mathbf{Lsize_{t-1}}$	-6.419 (7.545)	-7.588 (7.088)	-12.643** (6.006)	-10.593 (7.003)	-11.988** (5.931)	-20.570*** (5.575)
$\mathbf{ROA_{t-1}}$	0.770 (0.878)	1.447* (0.781)	0.974 (0.752)	1.630 (1.188)	-0.045 (0.798)	0.328 (0.613)
$\mathbf{MFUND_{t-1}}$	-0.582*** (0.155)	-0.613*** (0.173)	-0.379** (0.170)	-0.429*** (0.138)	-0.183 (0.133)	-0.138 (0.145)
$\mathbf{LTD_{t-1}}$	0.286 (2.406)	-0.470 (1.930)	-2.168 (1.421)	-0.597 (0.602)	-1.832** (0.775)	-0.684 (0.465)
$\mathbf{Provisions_{t-1}}$	0.466 (1.072)	0.847 (0.776)	0.231 (0.699)	0.968* (0.577)	0.481 (0.402)	-0.248 (0.335)
$\mathbf{CAP_{t-1} \times LIQ_{t-1}}$	-0.008*** (0.002)	-0.006*** (0.002)	-0.001 (0.002)	0.006** (0.003)	0.003 (0.002)	-0.003 (0.002)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP\_d}$	0.401 (0.249)	0.284 (0.212)	0.180 (0.267)	0.976*** (0.365)	0.762** (0.352)	1.064** (0.503)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	0.187 (0.156)	0.111 (0.154)	-0.169 (0.125)	-0.141 (0.214)	-0.034 (0.170)	-0.187* (0.110)
$\mathbf{CAP_{t-1} \times LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.018 (0.011)	-0.012 (0.008)	0.011 (0.014)	-0.013 (0.008)	-0.012* (0.007)	-0.009* (0.005)

Observations	774	890	1,023	864	1,328	1,971
Adjusted $\mathbf{R^2}$	0.117	0.119	0.093	0.244	0.206	0.170
No. of panels	178	200	225	275	395	532

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. All regressions include a constant term, yearly dummies and macroeconomic control variables, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly. LIQ_{t-1} is a one-period lagged ratio of liquid assets to short-term funding (LADSTF).
Source: own elaboration.

Table D.5. Robustness check of interaction effects of capital, liquidity and APP dummy on bank loans growth with an alternative measure of liquidity ratio

	$\boldsymbol{L_t}$ = Net loans (growth of logarithm)					
	Panel A: LIQ_{t-1} = Liquid assets to deposits and borrowing ratio (LATDB)			Panel B: LIQ_{t-1} = Liquid assets to customer deposits and short-term funding ratio (LADSTF)		
	Tier 1 ratio	TCR	ECR	Tier 1 ratio	TCR	ECR
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{L_{t-1}}$	-0.002 (0.047)	0.032 (0.045)	0.015 (0.042)	0.039 (0.037)	0.043 (0.042)	0.047 (0.036)
$\mathbf{CAP_{t-1}}$	0.019 (0.229)	-0.095 (0.191)	-0.903*** (0.342)	-0.187 (0.193)	-0.023 (0.174)	-0.570** (0.282)
$\mathbf{LIQ_{t-1}}$	0.393** (0.197)	0.247 (0.167)	0.488*** (0.102)	0.346** (0.142)	0.348*** (0.120)	0.519*** (0.076)
$\mathbf{Lsize_{t-1}}$	-6.381 (4.685)	-11.390** (4.556)	-21.859*** (4.691)	-9.872** (4.319)	-12.676*** (4.187)	-19.298*** (4.052)
$\mathbf{ROA_{t-1}}$	0.649 (1.145)	-0.551 (0.885)	0.355 (0.646)	0.854 (1.010)	-0.450 (0.724)	0.097 (0.561)
$\mathbf{MFUND_{t-1}}$	-0.305*** (0.078)	-0.260*** (0.083)	-0.207** (0.100)	-0.342*** (0.073)	-0.267*** (0.078)	-0.214** (0.087)
$\mathbf{LTD_{t-1}}$	-0.007 (0.572)	-1.133 (0.725)	-0.708 (0.600)	-0.602 (0.603)	-1.401** (0.662)	-0.626 (0.415)
$\mathbf{Provisions_{t-1}}$	-0.248 (0.339)	-0.464 (0.290)	-0.972*** (0.302)	0.539 (0.477)	0.235 (0.365)	-0.313 (0.304)
$\mathbf{CAP_{t-1}} \times \mathbf{LIQ_{t-1}}$	0.004 (0.006)	0.007* (0.003)	0.001 (0.003)	0.008*** (0.002)	0.004* (0.002)	0.000 (0.002)
$\mathbf{CAP_{t-1}} \times \boldsymbol{APP\_d}$	0.249 (0.158)	0.294** (0.137)	0.237 (0.167)	0.445** (0.174)	0.336** (0.153)	0.391 (0.240)
$\mathbf{LIQ_{t-1}} \times \boldsymbol{APP\_d}$	-0.286 (0.188)	-0.116 (0.165)	-0.150* (0.079)	-0.208 (0.167)	-0.142 (0.138)	-0.129** (0.063)

$\mathbf{CAP_{t-1}}$ $\times \mathbf{LIQ_{t-1}}$ $\times \boldsymbol{APP\_d}$	0.000 (0.007)	-0.004 (0.006)	-0.001 (0.006)	-0.006 (0.006)	-0.005 (0.005)	-0.006 (0.004)
Observations	3,742	4,155	5,546	4,931	5,586	8,063
Adjusted $\mathbf{R^2}$	0.260	0.228	0.190	0.244	0.200	0.160
No. of panels	1,140	1,251	1,667	1,350	1,530	2,022

Notes: The table reports estimated coefficients and statistics from fixed effects regression with interaction terms. Robust standard errors, clustered at the individual bank level, are reported in parentheses. All regressions include a constant term, yearly dummies and macroeconomic control variables, of which coefficients are not reported due to space limitations. Bank-specific variables are winsorized at the 1st and 99th percentiles. Observations involving mergers and acquisitions or abnormal growth in total assets are excluded.

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, accordingly.

Source: own elaboration.